Biological and Water Quality Monitoring

Autumn 2009 Final Report

prepared for City of Ryde

delivered by Analytical Services, Monitoring Services, Sydney Water

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Report Number: In Draft

File Reference: …\PM000094\City of Ryde\Autumn 2009\Report \COR Autumn 2009 Report - Final

July 2009

Executive Summary

This report for the Autumn 2009 period forms part of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy. During this period, Sydney Water collected macroinvertebrate and water chemistry samples from five creek systems of the Ryde Local Government Area (LGA). These were Archers, Shrimptons, Buffalo, Porters and Terrys creeks. The first round of sampling occurred on March 18th to 20th and the second round on April 27th and 29th and May 1st.

A total of 1,778 macroinvertebrates were collected and examined from the edge habitat of these creek systems in Autumn 2009. From this total, 40 different taxa were recorded. A total of 75 different taxa have been collected from the edge habitat of these creeks from Spring 2004 to the current period.

Macroinvertebrate results for Autumn 2009 indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinvertebrate communities. Similar results have been recorded in Spring 2004 to Spring 2008. Results of the univariate analyses were consistent with those of previous reports. Archers Creek appeared to have the richest stream health and Shrimptons Creek appeared to have the poorest stream health of the five creeks. The stream health is however similar across the five creeks. EPT taxa whilst, in low numbers were collected at all creeks except Shrimptons Creek. Only one AUSRIVAS EPT indicator taxa, Antipodoecidae (Trichoptera), was collected and this was from Porters Creek.

Multivariate analysis indicated a continuing trend of slight change in macroinvertebrate community composition between sampled seasons for each creek. Shrimptons Creek has provided the most variability in community structure over the 2005 to 2009 period, while Terrys Creek has provided the most stability over this period.

Indicative water quality results of Autumn 2009 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, dissolved oxygen and ammonium (NH4) although concentrations varied between creeks. ANZECC (2000) recommended concentrations were also exceeded for total phosphourus and faecal coliforms in Archers and Shrimptons creeks. These water quality results of Autumn 2009 suggest that whilst some similarity exists, influences on water chemistry in each creek are not the same across the City of Ryde. The impaired macroinvertebrate communities recorded in each of the five study streams reflect water quality failures highlighted in the comparison of water quality results to ANZECC (2000) guidelines and probably other unmeasured parameters.

Multivariate analysis of extrinsic water quality parameters for each creek highlighted rainfall as an influence on macroinvertebrate community structure. Multivariate analysis of extrinsic water quality parameters for all creeks highlighted two of the surrogate measures of storm water catchment drainage as an influence on macroinvertebrate community structure. They were Total Length of Pipe and Ratio of Number of Outlets/Catchment Area.

Errata Notice

An error was made in the presentation of the conductivity results in the Spring 2008 City of Ryde Biological and Water Quality Monitoring Final Report. Conductivity results for Spring 2008 were presented in mS/cm instead of µS/cm in both the results and appendix sections. Apologies are made for this error and the problem has been rectified for the Autumn 2009 Draft Report.

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1 Introduction

Sydney Water Corporation (Sydney Water) has developed this report in response to engagement under the City of Ryde Council Tender Number COR-EOC-05/07. This report for the Autumn 2009 period forms part of the City of Ryde Council's Biological and Chemical Water Quality Monitoring Strategy.

Under the strategy, Sydney Water Corporation (Sydney Water) carries out macroinvertebrate and water chemistry sample collection, analysis and reporting for the main creek systems of the Ryde LGA. This strategy was originally planned as a seven-year program, in which all five creeks would be monitored for the first two years. For the remaining five years the intention was to target two of the five creeks each year on a rotational basis. In Spring 2006, Ryde Council agreed to continue regular monitoring of all five sites for the remainder of the program after discussions during the Spring 2006 presentation. This would more accurately measure natural variations in stream health during drier and wetter hydrological conditions that may occur over the duration of the program. This Autumn 2009 report begins the sixth year of the program. Macroinvertebrates and water chemistry were each sampled in March and April/May 2009 at all five sites. Additional water quality was conducted as per variations.

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

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

2 Study Area

2.1 Site locations

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

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

Additional water quality sites for Shrimptons, Porters and Buffalo creeks were sampled for various analytes in Autumn 2009, refer to Table 8 for these locations. Additional stormwater water quality sites were sampled in Autumn 2009, refer to Table 9 for these locations.

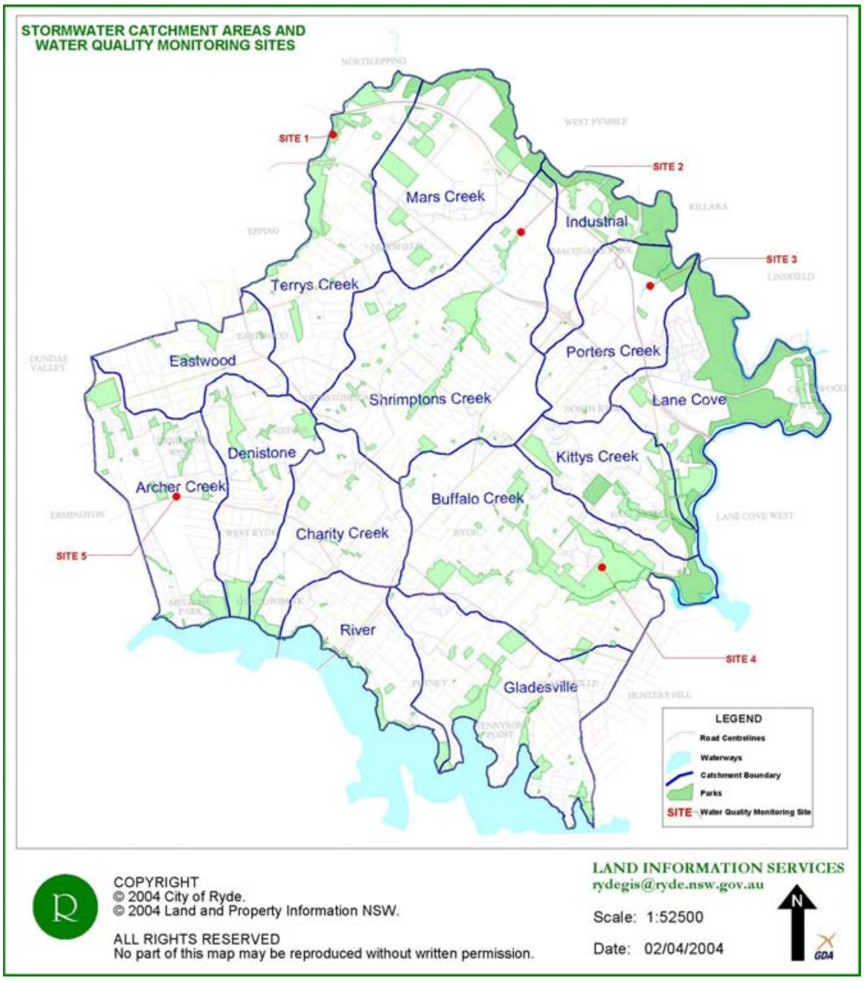


Figure 1 Site locations of the Biological and Chemical Water Quality Monitoring Strategy of the City of Ryde

2.2 Autumn 2009 sampling events

Two sampling events were conducted in Autumn 2009 for the City of Ryde Biological and Chemical Water Quality Monitoring Strategy. Sampling was conducted at all five creeks in each of the following periods:

- March 18th to 20th 2009
- April 27th, 29th 2009 and May 1st 2009

Figure 2 Archers Creek in Autumn 2008 showing completed rehabilitation work

3 Methodology

3.1 Macroinvertebrate sampling

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

Three edge habitat samples were collected from each site within a pre-selected area in September and October within the season of Autumn 2009 as specified in the City of Ryde Biological and Chemical Water Quality Monitoring tender document COR-EOC-05/07. The 'edge' habitat is defined as areas with little or no current. These areas were sampled with a hand-held dip net with 320 mm by 250 mm opening and 0.25 mm (250 µm) mesh that conformed to ISO 7828-1985 (E). The net was swept from open water towards the shore, working over a bank length of about 10 m moving in an upstream direction. In the process, deposits of silt and detritus on the stream bottom were stirred up so that benthic animals were suspended and then caught in the net.

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

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

3.2 Macroinvertebrate sample processing

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

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

3.3 Water quality sampling

Water chemistry was sampled once each month within Autumn 2009 (March and May) 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, Dissolved Oxygen	WTW meter
Temperature	Thermometer

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-NU43
Total Kjeldahl Nitrogen	0.1 mg/L	Calculation
Ammoniacal Nitrogen	0.01 mg/L	APHA 4500-NU40
Total Nitrogen	0.1 mg/L	APHA 4500-NU57
Conductivity	0.1 mS/m	APHA 2510 B

Additional water quality sample collection and measurements in Autumn 2009 on Shrimptons, Buffalo and Porters creeks allowed spatial comparisons of collected variables on each creek in an attempt to investigate potential dry weather point sources.

While not to the sampling frequency suggested by ANZECC (2000), the water quality results did allow characterisation 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 was substituted from West Pymble 66189 and/or Turramurra 66158 Bureau of Meteorology Stations. This was done on the recommendation of the Bureau of Meteorology.

3.5 Comparison with historical data

The City of Ryde Council Tender Number COR-EOC-05/07 requested compilation and analysis of all historic raw data (where comparable) back to 2004 and, where data was available back to 2001, for assessment with Autumn 2009 study data to provide a temporal evaluation of ecological health of the five creeks under study. Ecowise supplied raw macroinvertebrate and water chemistry data (Spring 2004 to Autumn 2006) and together with Spring 2006, Autumn 2007, Spring 2007, Autumn 2008, Spring 2008 and Autumn 2009 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 2009

	Sampling period																																																	
	Spring 2004					**Autumn 2005**					**Spring 2005**					**Autumn 2006**					**Spring 2006**					**Autumn 2007**					**Spring 2007**					**Autumn 2008**					**Spring 2008**					**Autumn 2009**				
	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archers Ck
Macroinvertebrates	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Alkalinity (Total)	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ammonia NH3-N						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Conductivity (mS/m)						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DO (mg/L)	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Faecal Coliform	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Oxidised Nitrogen NOx-N						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
pH	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Temp	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TN						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Dissolved Solids	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Kjeldahl Nitrogen						*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Total Phosphorus	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Turbidity	*	*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

3.6 Data analyses

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

Univariate methods

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

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

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

EPT richness

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

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

SIGNAL-SF

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

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

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

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

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

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

AUSRIVAS predictive models OE50 output

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

AUSRIVAS models can incorporate data taken from pool edge or riffle habitats. The paucity of riffle habitats at the sites under study by the City of Ryde in sampling conducted for the program to date preclude use of the riffle models. Ecowise collected only four riffle samples between Spring 2004 and Autumn 2006. Hence in comparison of Autumn 2009 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, SIMPROF test
- SIMPER
- BIOENV

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

Autumn 2009 macroinvertebrate samples were compared in an ordination with 2005, 2006, 2007 and Autumn 2008 data for all creeks of the monitoring program to look at context of community composition. Please note Spring 2004 data were not included in these comparisons as comparable sites in Buffalo and Porters creeks were not sampled in Spring 2004 and also not sampled in Spring 2004 were all water quality variables at Archers, Shrimptons and Terrys creeks (Table 3).

Macroinvertebrate data of each creek were also explored by a comparison of data from the seasons, Autumn 2005, Spring 2005, Autumn 2006, Spring 2006, Autumn 2007, Spring 2007, Autumn 2008, Spring 2008 and Autumn 2009.

Classification, Ordination and SIMPROF test

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. The SIMPROF test provides a way to view community structure differences and similarities between samples and overcome the limitation of classification analysis. SIMPROF results have been overlaid onto classification result output (dendrogram) with red lines indicating no difference between samples and the black line indicating a difference in community structure. SIMPROF test groups can be checked against ordination results. 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. When Ordination and SIMPROF test results produce similar overall patterns the analysis can be considered reliable.

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

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

SIMPER

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

BIOENV

The extrinsic physical and chemical characteristics of the creeks were compared with the intrinsic macroinvertebrate community structure using the BIOENV routine. The underlying similarity matrix was constructed with the normalised Euclidean Distance association measure option. This option enabled a comparison of water quality variables without undue weight being assigned by differing unit scales. Log10 transformations were applied to: faecal coliforms; ammonia; oxidised nitrogen; total phosphorus; total kjeldahl nitrogen; total nitrogen; turbidity; conductivity; and total dissolved solids. All other physical and chemical variables listed in Table 2 were untransformed in the BIOENV analysis.

4 Results

4.1 Water quality & site observations

The field and laboratory results for water quality parameters measured at Archers, Shrimptons, Buffalo, Porters and Terrys creeks in Autumn 2009 are presented in Table 7. Whilst not to the sampling frequency suggested by ANZECC (2000), it 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 from Shrimptons, Buffalo, Terrys and Archers creeks during Autumn 2009 were all below the 85% recommended level within ANZECC (2000) for the protection of aquatic ecosystems. In March and April 2009 Porters Creek recorded dissolved oxygen saturation concentrations within ANZECC (2000) recommended levels, 92% and 95% respectively. Porters Creek has the highest overall historical average of dissolved oxygen saturation (87.5%, Table 7) in the period Spring 2004 to Spring 2008. In March Shrimptons Creek recorded 2% dissolved oxygen saturation. Shrimptons Creek has the lowest overall historical average dissolved oxygen saturation (38%, Table 7).

Additional water quality sample collection upstream of Shrimptons, Buffalo and Porters creeks sought to investigate potential dry weather point sources of pollution. No dissolved oxygen saturation at additional Shrimptons Creek sites met ANZECC (2000) recommended levels (range of 48% to 80%, Table 8). The results showed no distinct pattern in relation to the downstream core site. Both the upstream additional sites on Buffalo Creek however recorded higher dissolved oxygen saturation (range of 62% to 87%) than the downstream core site (49% and 75%, Table 7 and Table 8). In March and April the Main Line Channel at Porters Creek was the only site on this creek to not meet ANZECC (2000) dissolved oxygen saturation (79% and 29%).

Bacteriological results were compared with ANZECC (2000) recommended levels 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. In March and April Archers Creek recorded elevated faecal coliform concentrations of 4,800 and 1,700 cfu/100mL. These results are above the ANZECC (2000) recommended concentration of 1,000 cfu/100mL. In March Shrimptons and Porters creeks also had elevated faecal coliform concentrations of 1,200 and 3,000 cfu/100mL respectively. Of these three creeks Porters Creek had the only historical average faecal coliform concentration exceed ANZECC (2000) recommended concentrations. Within the additional sample sites for Autumn 2009 Shrimptons Creek Quarry Road was the only site with a distinctly notable non-compliant result in March 2009 with a faecal coliform concentration of 67,000 cfu/100mL.

This is 67 times the recommended ANZECC (2000) concentration of 1,000 cfu/100mL.

Turbidity concentrations were within the ANZECC (2000) recommended levels for all core site from Terrys, Shrimptons, Porters, Buffalo and Archers creeks and additional samples taken from Shrimptons, Porters and Buffalo creeks in Autumn 2009. Historical turbidity average levels for all five core creek sites are also well below ANZECC (2000) recommended levels of 50 NTU.

Total oxidised nitrogen as a measure of nutrient levels were elevated above ANZECC (2000) recommended concentrations of 40 µg/L in Autumn 2009 for all core samples at Terrys, Shrimptons, Porters, Buffalo and Archers creeks. Porters Creek consistently performed the worst with total oxidised nitrogen concentrations of 1,290 µg/L in March and 1,350 µg/L in April and was above the historical average of 1,012 µg/L. Archers Creek was the other site to note with unusually high Total Oxidised Nitrogen concentrations of 1,380 µg/L in March and 860 µg/L in April. These are the highest concentrations of total oxidised nitrogen recorded to date at this site and are well above the historical average of 175 µg/L. Shrimptons Creek Bridge Street in March 2009 (20 ug/L) and Porters Creek Main Branch Channel April 2009 (30µg/L) were the only two additional sites to conform to ANZECC (2000) total oxidised nitrogen concentrations. Porters Creek Main Branch at Wicks Road exceeded the recommended total oxidised nitrogen concentrations of 40 µg/L (ANZECC, 2000) by over thirty times in March (1,480 µg/L) and April (1,500 µg/L). These results did not show any consistent pattern with distance travelled downstream.

Total nitrogen concentrations for Shrimptons, Porters, Buffalo and Archers creeks exceeded the ANZECC (2000) recommended concentrations of 500 µg/L for all samples in Autumn 2009, except Shrimptons Creek in April, which recorded 480 µg/L. Porters Creek considerably exceeded ANZECC (2000) recommended concentrations for total nitrogen in Autumn 2009 with 2,780 µg/L in March and 2,360 µg/L in April. These results are consistent with the historical average of 2,456 µg/L. Again Archers Creek was the other site to note with unusually high total nitrogen concentrations of 3,140 µg/L in March and 1,130 µg/L in April 2009. The March 2009 result for Archers Creek is the highest recorded concentration of total nitrogen to date at this site and is six times higher than the historical average of 516 µg/L. Additional sampling sites showed varied results. All additional Shrimptons Creek sites complied with total nitrogen recommended concentrations of 500 µg/L (ANZECC, 2000) in Autumn 2009 except Quarry Road with 7060 µg/L in March and 850 µg/L in April. No additional upstream Buffalo Creek sites conformed to ANZECC (2000) recommended total nitrogen concentrations in Autumn 2009. Main Branch Channel was the only Porters Creek conforming site with ANZECC (2000) recommended concentrations in Autumn 2009 with 470 µg/L and 460 µg/L respectively.

Ammonium concentrations were below the ANZECC (2000) recommended concentrations of 20 µg/L during Autumn 2009 at Shrimptons, Buffalo and Terrys creeks. Similar results were found for Terrys and Shrimptons creeks in Autumn 2008. All three creeks have non-complaint historical ammonium average concentrations (Table 7). Archers Creek had a considerably high ammonium concentration of 1,220 µg/L in March 2009, which is over 60 times the ANZECC (2000) recommended concentration. As for total oxidised nitrogen, total kjeldahl nitrogen and total nitrogen for Archers Creek this is the highest recorded concentration of ammonium to date at this site. Porters Creek in Autumn 2009 had consistently non-compliant ammonium concentrations of 820 µg/L in March and 860 µg/L in April with relation to the historical average of 831 µg/L. Additional sampling sites upstream of core sites showed no real trends with respect to ammonium concentrations and distance upstream. The most notable result was in March at Shrimptons Creek Quarry Road with an ammonium concentration of 5800 µg/L. This is the highest Ammonia concentration ever recorded for this site and over all sites for this program. These results are consistent with the high concentrations of faecal coliforms, total oxidised nitrogen, total kjeldahl nitrogen, total nitrogen and total phosphorus for Shrimptons Creek Quarry Road for March 2009. Ammonium concentrations had returned to negligible concentrations (10 µg/L) in the April 2009 sample.

Total phosphorus concentrations were within ANZECC (2000) recommended concentrations of 50 µg/L for Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Autumn 2009 except Archers Creek in March (171 µg/L). Of the additional sites, non-compliant total phosphorus concentrations were also found at Shrimptons Creek Quarry Road for both samples in Autumn 2009 (625 µg/L and 69 µg/L) and Buffalo Creek u/s Burrows Park in April 2009 (62 µg/L).

Conductivity (as a measure of salinity) was within the ANZECC (2000) recommended range for all samples at Terrys, Shrimptons, Porters, Buffalo and Archers creeks in Autumn 2009. All results were above the lower limit of 125 µS/cm. Historically Porters Creek, with average conductivity concentrations of 2,486 µS/cm, is the only creek to average outside the upper limit of 2,200 µs/cm (ANZECC, 2000).

The pH was within the recommended levels (ANZECC, 2000) for all samples at all creeks for Autumn 2009, as are the historical averages.

Alkalinity recordings for Autumn 2009 were similar across all five creeks and were reflective of historical averages.

Total dissolved solids were also similar across all five creeks in Autumn 2009. Porters Creek recorded levels well below its historical average.

Table 7 ***Water quality results for Autumn 2009 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**	**Cond. µS/cm**	**TDS mg/L**	**pH**	**DO % Sat**	**Temp. °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 CREEK	March	4800	1220	1380	171	1760	3140	79	2.2	278	278	7.4	60.0	17.8
	April	1700	<10	860	31	270	1130	67	2.7	472	269	7.8	79.0	12.8
	Historical*	678	37	175	49	342	516	73	4.5	437	254	7.0	61.0	17.5
SHRIMPTONS CREEK	March	1200	<10	90	43	510	600	70	2.8	377	220	7.3	2.0	19.4
	April	350	<10	140	34	340	480	82	2.1	481	289	7.5	72.0	14.5
	Historical*	663	41	169	65	502	650	64	9.8	349	209	6.9	38.0	16.8
BUFFALO CREEK	March	240	20	580	31	520	1100	89	7.0	886	490	7.3	49.0	17.8
	April	92	10	330	20	310	640	72	4.3	708	408	7.5	75.0	14.0
	Historical*	729	72	282	41	362	615	81	10.6	680	389	7.3	58.0	17.0
PORTERS CREEK	March	3000	820	1290	27	1490	2780	106	2.9	487	266	7.8	92.0	20.4
	April	190	860	1350	21	1010	2360	86	4.0	449	268	7.8	95.0	16.0
	Historical*	2509	831	1012	27	1291	2456	69	5.4	2486	1533	7.5	87.5	18.1
TERRYS CREEK	March	67	10	260	25	350	610	72	2.9	525	282	7.6	75.0	18.0
	April	140	10	180	20	240	420	65	2.1	518	300	7.6	73.0	12.5
	Historical*	359	90	140	41	381	522	57	4.9	368	215	7.1	57.5	15.6

Historical = Average of historical water quality data for samples taken from Spring 2004 – Spring 2008.*

Table 8 Water quality results at additional COR sites for Autumn 2009 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**	**Cond. µS/cm**	**TDS mg/L**	**pH**	**DO % Sat**	**Temp. °C**
ANZECC (2000)	**Aquatic Ecosystem**	**-**	**20**	**40**	**50**	**N/A**	**500**	**N/A**	**50**	**125-2200**	**N/A**	**6.8-8.0**	**85-110**	**-**
	Secondary Contact	**1000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Shrimptons Creek	**Historical***	663	41	169	65	502	650	64	9.8	349	209	6.9	38.0	16.8
Shrimptons Creek Kent Road	March	2300	10	60	41	440	500	60	3.9	469	255	7.2	48.0	18.8
	April	570	10	50	25	280	330	70	1.7	597	350	7.2	57.0	14.8
Shrimptons Creek Bridge Street (d/s Santa Rosa Park)	March	38	10	20	24	350	370	80	3.4	587	320	7.3	62.0	18.8
	April	90	10	50	27	320	370	87	4.0	735	426	7.2	80.0	14.8
Shrimptons Creek Quarry Road (u/s Santa Rosa Park)	March	67000	5800	670	625	6390	7060	104	2.6	769	396	7.5	47.0	20.4
	April	1900	10	410	69	440	850	80	4.1	864	504	7.5	52.0	16.6
Buffalo Creek	**Historical***	729	72	282	41	362	615	81	10.6	680	389	7.3	58.0	17.0
Buffalo Creek d/s Burrows Park	March	660	60	900	43	510	1410	95	7.7	1572	882	7.3	62.0	18.5
	April	820	10	680	35	330	1010	106	7.3	1403	765	7.3	87.0	16.1
Buffalo Creek u/s Burrows Park	March	490	60	1240	48	430	1670	102	2.7	1308	742	8.9	80.0	18.3
	April	1500	10	850	62	300	1150	104	8.2	1182	658	7.7	86.0	15.6
Porters Creek	**Historical***	2509	831	1012	27	1291	2456	69	5.4	2486	1533	7.5	87.5	18.1
Porters Creek Spur Branch	March	150	70	280	20	450	730	80	3.4	379	221	7.5	99.0	20.8
	April	46	90	330	15	380	710	66	5.1	342	195	7.6	101.0	16.7
Porters Creek Main Branch Channel (COR staff site)	March	210	40	150	39	320	470	33	11.0	105	61	7.0	79.0	20.9
	April	31	220	30	31	430	460	119	2.0	353	219	7.2	29.0	15.1
Porters Creek Main Branch Wicks Road	March	840	30	1480	27	350	1830	86	3.3	556	326	7.9	93.0	21.4
	April	160	30	1500	22	200	1700	84	2.4	543	334	7.7	89.0	15.7

Historical = Average of historical water quality data for Core Site samples taken from Spring 2004 – Spring 2008.*

Table 9 Water Quality results for COR additional Stormwater sites for Autumn 2009

Parameter Units		TN ug/L	TP µg/L	TSS mg/L
ANZECC (2000)	**Aquatic Ecosystem**	**500**	**50**	**6-50**
	Secondary Contact	-	-	-
Unnamed Ck d/s Proposed works	May	270	23	<2
	June*	530	51	<2
Storm water outlet 2 Amiens St	May	nr	nr	nr
	June*	600	62	6
Storm water outlet @ Ashburn Place	May	5800	1040	8
	June*	1310	140	<2
Storm water outlet d/s Wetland	May	150	95	14
	June*	430	40	6
Storm water outlet u/s Wetland	May	1610	64	5
	June*	1240	122	2
Storm water outlet @ 50 Higginbotham Rd	May	920	36	2
	June*	1130	56	8

nr = This site only has water during wet weather events hence was dry during time of sampling

* = Sampling was completed during a wet weather event

Figure 3 CRDP1 Sampling location Autumn 2009

4.2 Rainfall Data

Daily rainfall data from the Marsfield Bureau of Meteorology Station number 066156 presented below displays rainfall for the five months before and during the Autumn 2009 sampling period. During the period 616 mm of rain fell within a range of 16 mm to 220 mm per month. The annual rainfall for 2008 was 1,203 mm, which was one of the highest annual rainfall recorded for this program (Table 10).

Table 10 Total rainfall by year

Year	Rainfall (mm)
2003	1262
2004	905
2005	788
2006	730
2007	1430
2008	1203
2009 to date	489

Heavy rain fell during mid February and early March before the Autumn 2009 sampling began. This contributed to a total of 325 mm of rain in the three months preceding sampling. In between March and April 2009 sampling occasions there were several periods of heavy rain. This heavy rain also resulted in delays in the sampling roster due to postponed field trips.

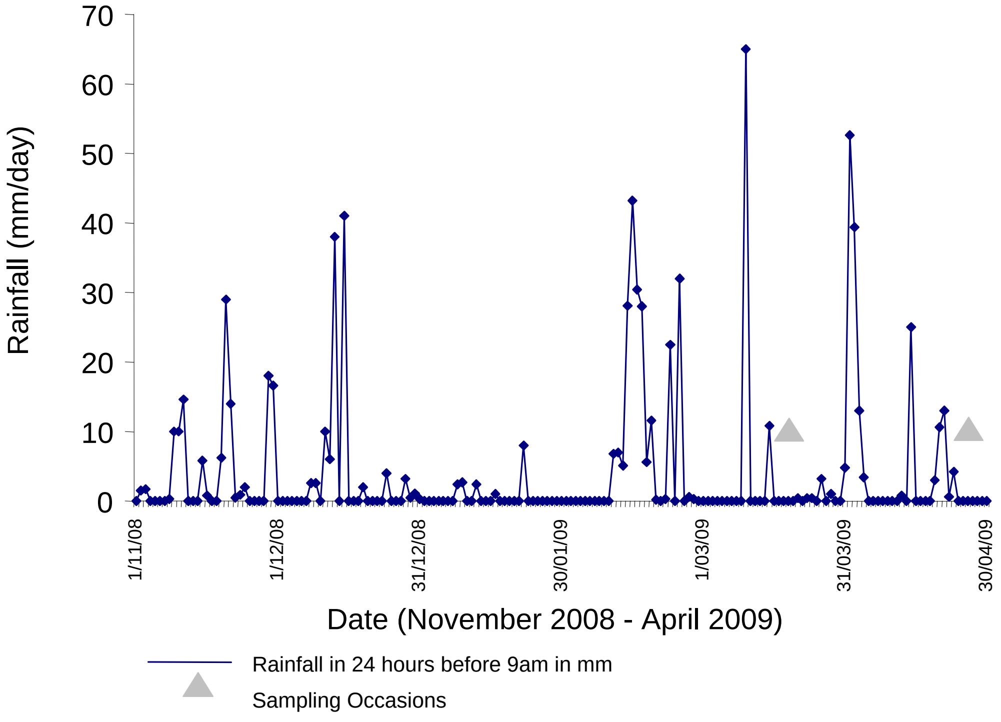


Figure 4 Daily rainfall data 1st November 2008 to 30th September 2008 with sampling occasions indicated

4.3 Macroinvertebrate Results

General Characteristics of Aquatic Macroinvertebrate Assemblages

- A total of 1,778 macroinvertebrates were collected and examined from all five sites in Autumn 2009.
- From this total, 40 taxa were recorded.
- A total of 75 taxa have been collected from the edge habitat of all five creeks from Spring 2004 to Autumn 2009.
- This compares with 157 taxa of the *SIGNAL-SF* index of the greater Sydney region, although this total includes taxa from the edge habitat as well as all other stream habitats.

Comparisons of taxa collected in each creek between the sampling period of Spring 2004 to Spring 2008 and Spring 2004 to Autumn 2009 indicate additional taxa have been collected in Autumn 2009 at Archers, Buffalo, and Terrys creeks (Table 11). With additional seasonal sampling planned under the strategy it is likely further additional taxa will be recorded.

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

Sampling Seasons	Archers	Shrimptons	Buffalo	Porters	Terrys
Spring 04 - Spring 08	50	46	48	49	55
Spring 04 - Autumn 09	51	46	49	49	56

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

The larvae of the Sydney Hawk Dragonfly *Austrocordulia leonardi* (listed as endangered under the *FM Act*), and the Adams Emerald Dragonfly *Archaeophya adamsi* (listed as vulnerable under the *FM Act 1994*), are potentially found in the Sydney Basin region. Neither of these macroinvertebrates were observed in Autumn 2009 samples and are not listed in historical data.

EPT richness

The average EPT taxa richness for each of the five creeks was summarised by sampling seasons (Figure 5). This summary indicated that EPT taxa are rarely collected from the five sampled creeks. Porters Creek has the highest EPT average, yet does not average a single EPT taxa per sampling period (Figure 6). Autumn 2009 saw occurrences of EPT taxa similar to previous sampling periods for all five creeks sampled. Archers and Porters creeks were the only creeks to average more than single EPT taxa during Autumn 2009. Shrimptons Creek recorded no EPT taxa in Autumn 2009 and Terrys Creek had a very low occurrence. Historically, both creeks have the lowest EPT taxa per sampling season (Figure 5).

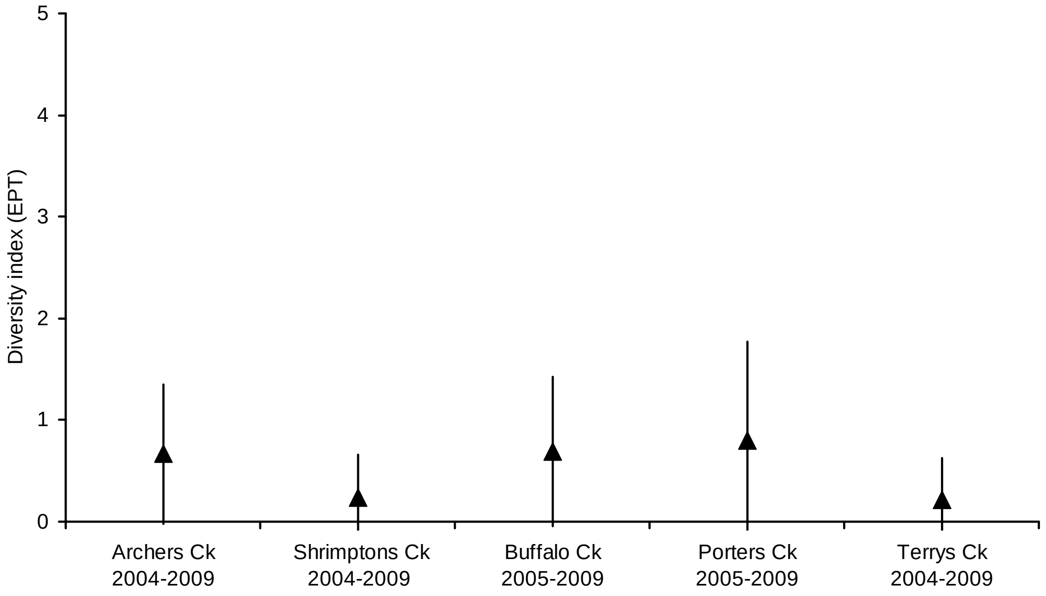
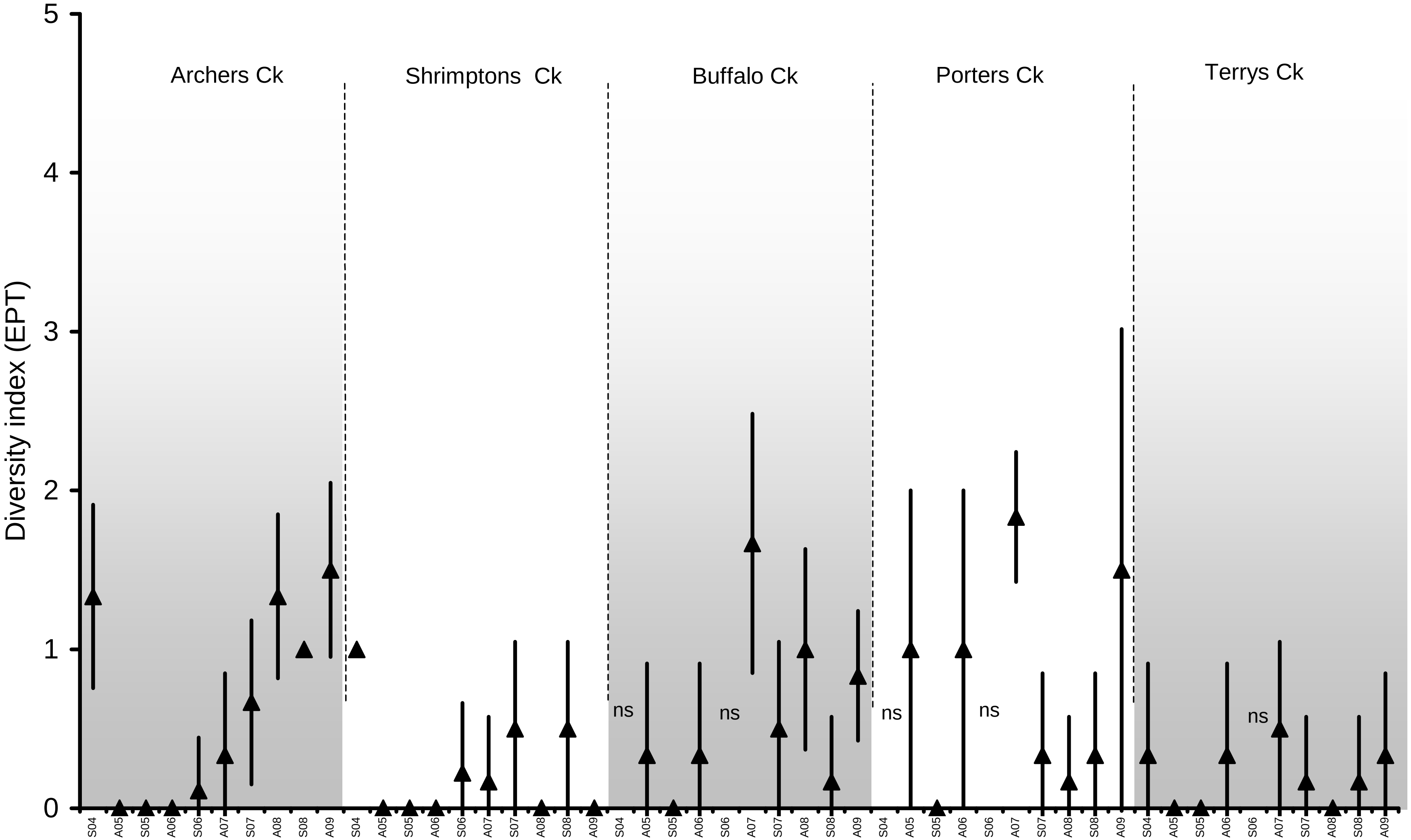


Figure 5 EPT richness of all creeks of monitoring program



ns not sampled

Figure 6 EPT richness by season

SIGNAL-SF

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

Average stream health increased slightly in Autumn 2009 for Buffalo, Porters and Terrys creeks compared to Spring 2008. Archers and Shrimptons creeks average stream health had only very slight changes compared to Spring 2008 (Figure 8).

Archers Creek narrowly had the highest average stream health when assessed with SIGNAL-SF from macroinvertebrate sampling between Spring 2004 and Autumn 2009 (Figure 7). 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 7). The larger range recorded for Shrimptons Creek reflects the temporal change in stream health recorded from 2004 to 2009 in Figure 8.

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

Shrimptons Creek stream health steadily improved between Autumn 2005 and Autumn 2007 but started decreasing in Spring 2007. Average stream health for Shrimptons Creek from Autumn 2008 to Autumn 2009 has gone back to a similar health to that of Autumn 2005.

Archers Creek average stream health has been showing a minor trend of being higher in autumn seasons and lower in spring seasons from Spring 2004 to Spring 2008. Archers Creek stream health for Autumn 2009 was comparable (higher by 0.02) to Spring 2008, which doesn’t fit in with the aforementioned trend (Figure 8).

Buffalo Creeks stream health dropped in Spring 2008 to the lowest it has been since first sampled in Autumn 2005, placing it in the probable severe organic pollution category. The Autumn 2009 average stream health for Buffalo Creek returned to be within the stream health range that had been previously recorded from Autumn 2005 to Autumn 2008 (Figure 8).

Porters Creek stream health increased in Autumn 2009 compared to Spring 2008. Porters Creek has indicated that it may have a seasonal trend like that of Archers Creek, evident since Autumn 2007. With missing data points however, further data collection is required to establish this trend (Figure 8).

The range of stream health for Terrys Creek is relatively narrow and Autumn 2009 falls within the range previously recorded. Stream health had been steadily declining since Spring 2005 in Terrys Creek, however in Autumn 2009 stream health has increased slightly (Figure 8).

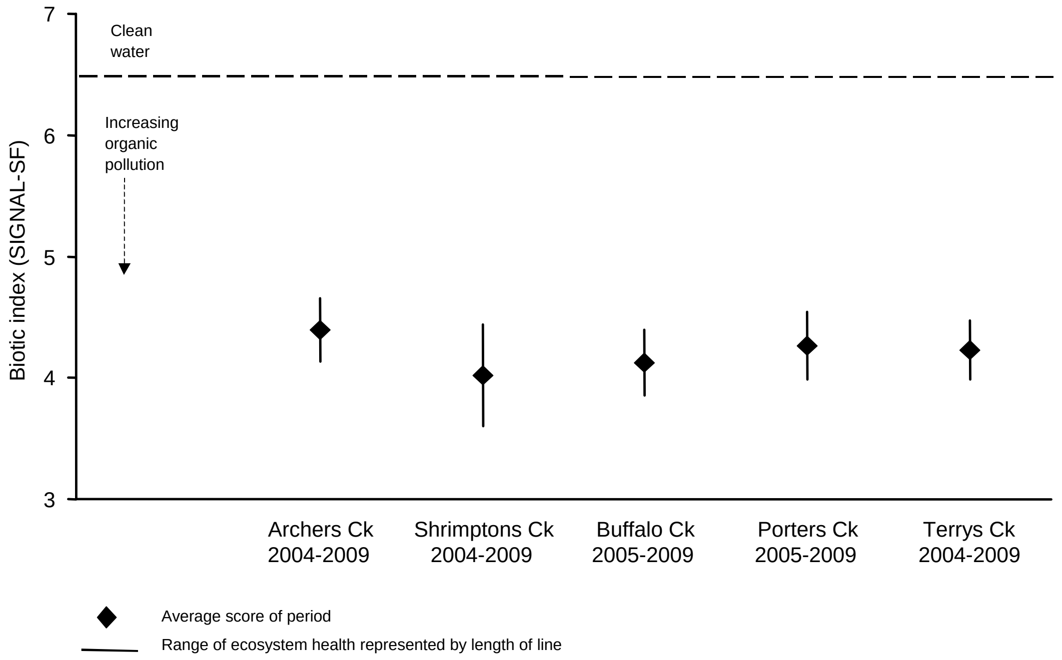


Figure 7 SIGNAL-SF of all creeks of monitoring program

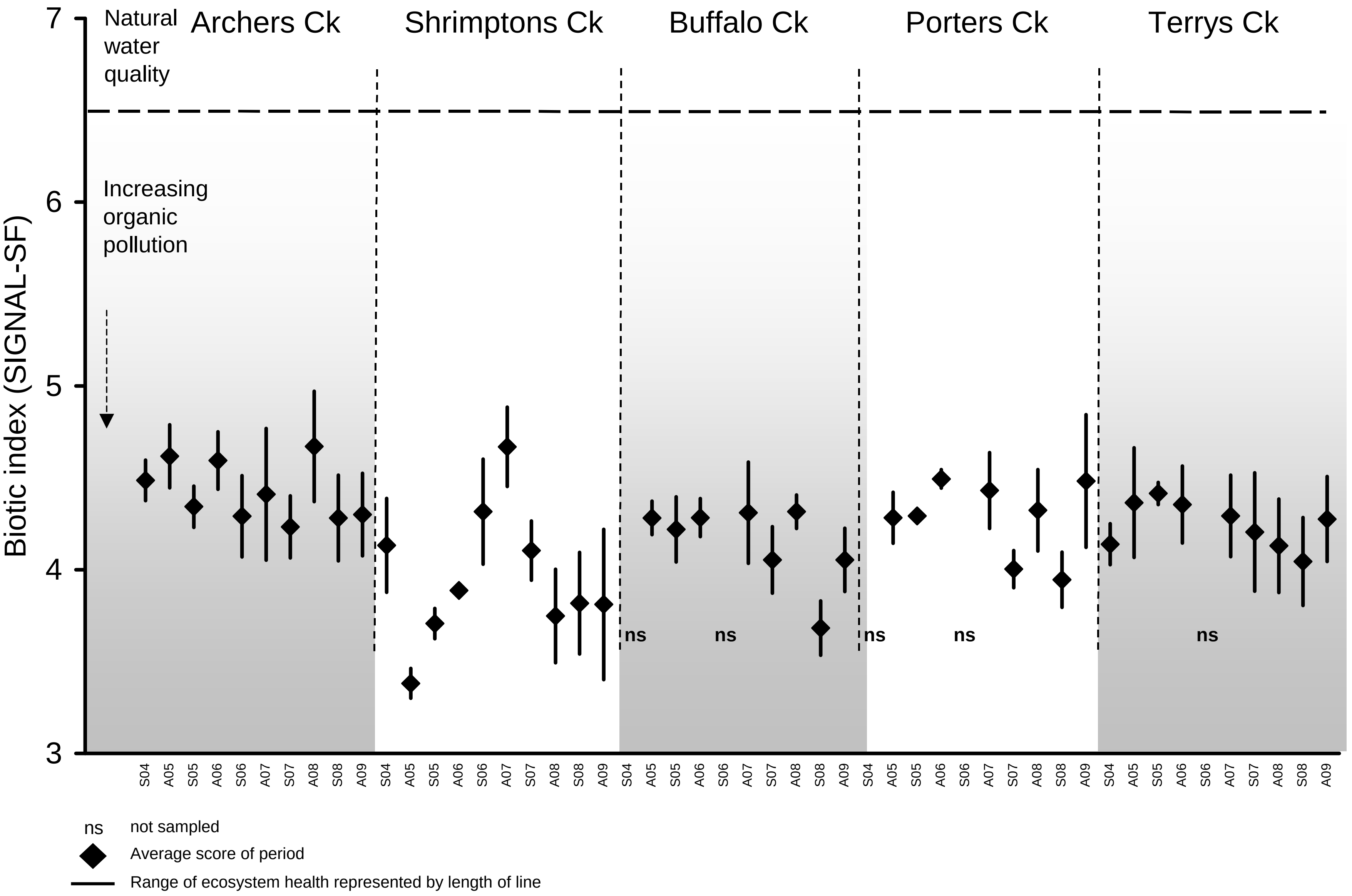


Figure 8 ***SIGNAL-SF by season***

AUSRIVAS OE50

The addition of Autumn 2009 data to the Autumn edge AUSRIVAS OE50 model allowed for the Combined season edge output to be updated, as this is presented on a financial year basis.

The 2009 Autumn edge and 2008/09 combined season model does not include an average score for OE50 for Archers Creek. The model output described it as being *outside the experience of the model*. This also occurred in the Autumn 2008 output but at that time it still had an average score for the combined season output.

The Autumn 2009 average scores for Autumn edge AUSRIVAS OE50 were within previously recorded average stream health for Shrimptons, Buffalo, Porters and Terrys creeks. Terrys Creek average health increased slightly placing it in the significantly impaired band. This was up from the severely impaired band that it was placed in Autumn 2008. Shrimptons, Buffalo and Porters creeks all had only minimal changes in average stream health. These three creeks all fall within the severely impaired band, and did so in Autumn 2008 (Figure 10,Table 5 and Table 6).

The Autumn edge AUSRIVAS OE50 model output suggested that the stream health across all five creeks are similar, with Shrimptons Creek being the slightly more impaired of the five creeks. All five creeks show reasonable variation over time particularly Shrimptons and Porters creeks (Figure 13).

The output for all creeks of the Autumn 2009 edge AUSRIVAS OE50 model was higher than the output of the Spring 2008 edge AUSRIVAS OE50 model (except Archers Creek). This trend has generally occurred for all creeks over time (Figure 9 and Figure 10).

Combined season edge AUSRIVAS OE50 average scores decreased for Shrimptons and Buffalo creeks and increased for Porters and Terrys Creeks. All average scores were within the stream health range of previous combined seasons for the four creeks and were placed in the severely impaired band (Figure 11, Table 5 and Table 6).

Combined season edge AUSRIVAS OE50 model output suggested that the stream health is similar across all five creeks with similar variability over time. Archers Creek stream health is slightly higher and is placed in the significantly impaired band, with the other creeks placed in the severely impaired band (Figure 14, Table 5 and Table 6).

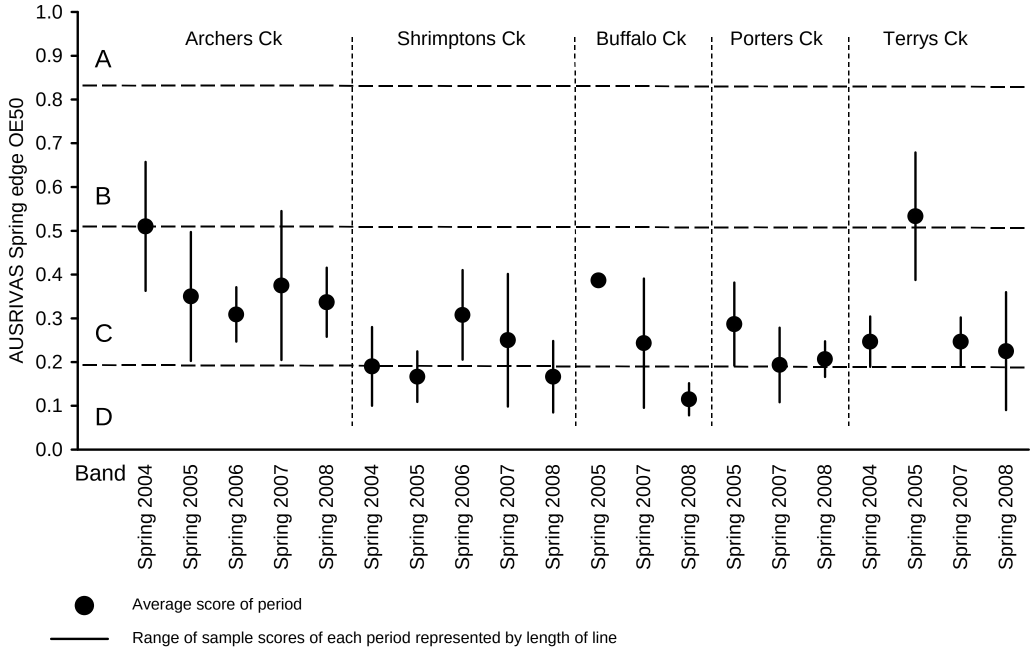


Figure 9 AUSRIVAS OE50 of all creeks from Spring edge model

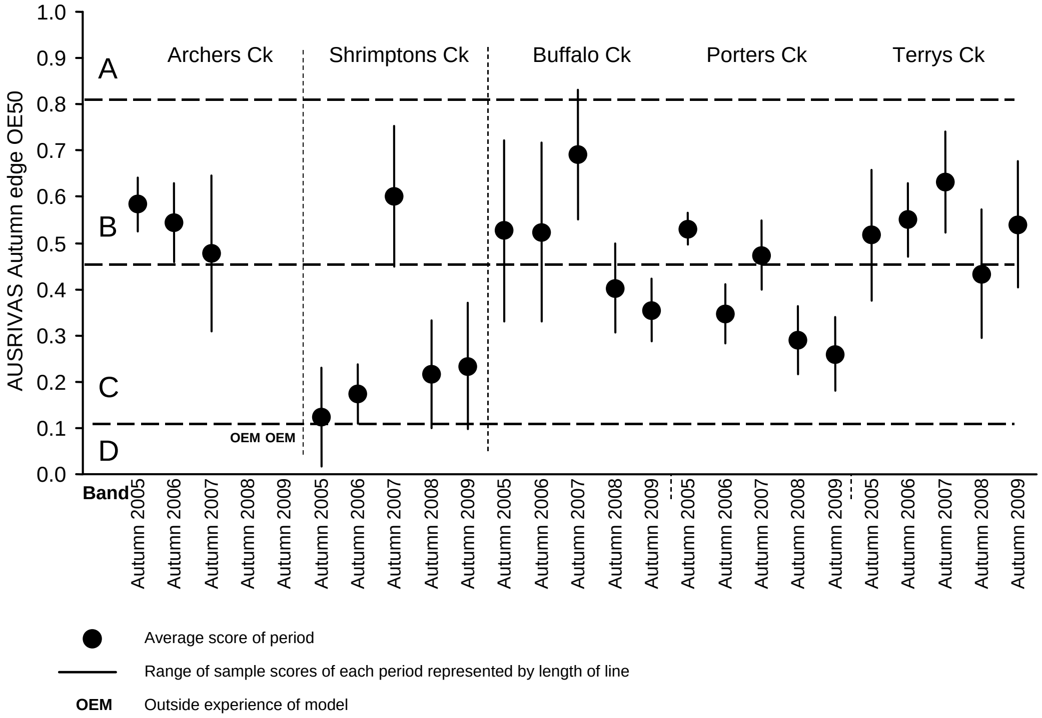


Figure 10 AUSRIVAS OE50 of all creeks from Autumn edge model

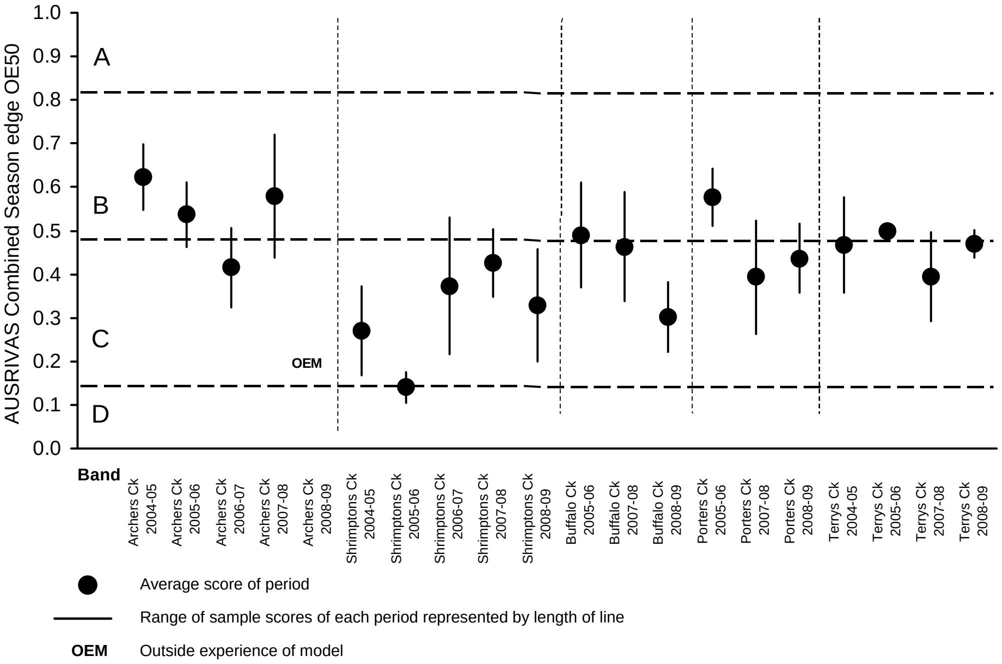


Figure 11 AUSRIVAS OE50 of all creeks from combined season edge model (with financial year data combined)

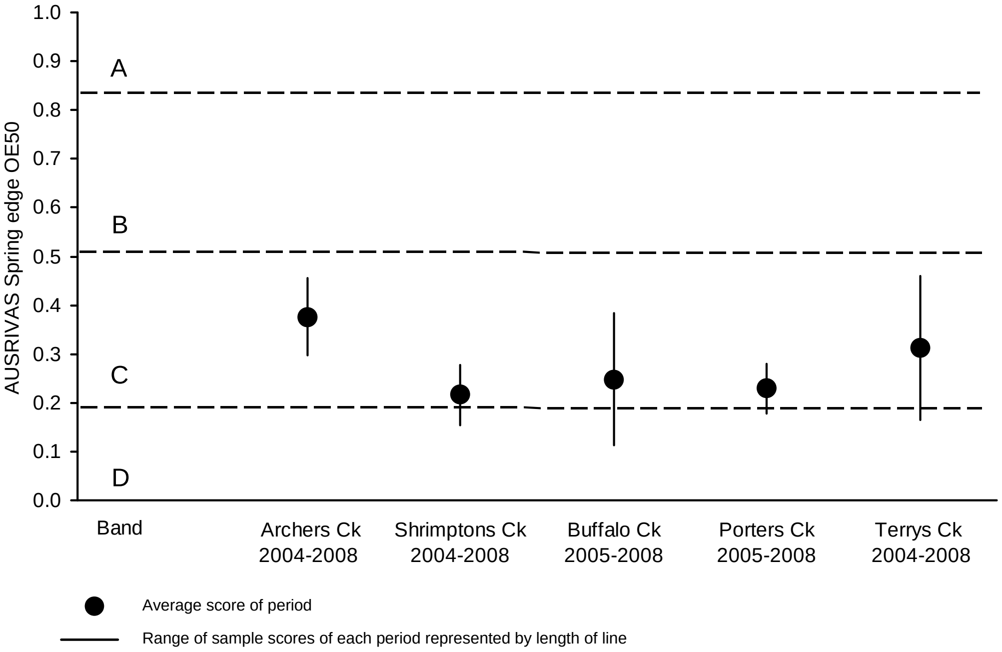


Figure 12 AUSRIVAS OE50 summary of all creeks from Spring edge model

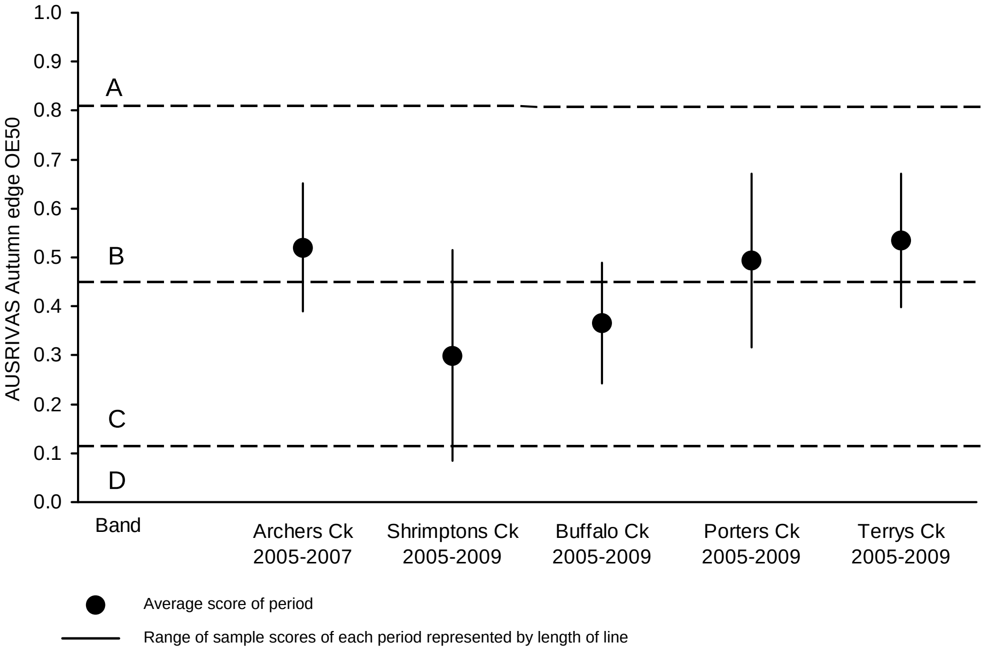


Figure 13 AUSRIVAS OE50 summary of all creeks from Autumn edge model

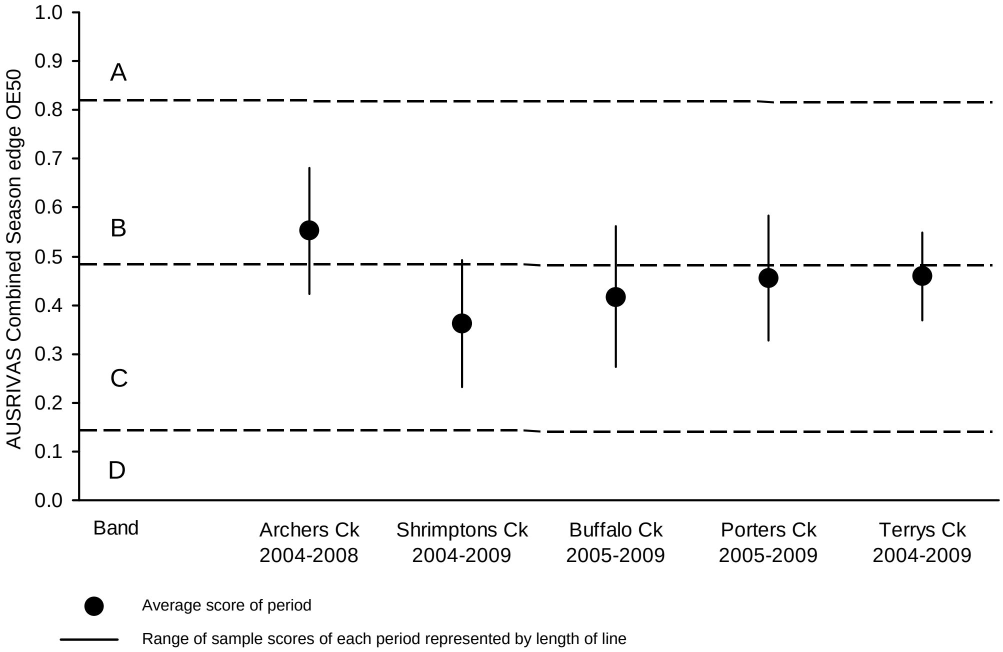


Figure 14 AUSRIVAS OE50 summary of all creeks from combined season edge model (with financial year data combined)

EPT Indicator taxa from AUSRIVAS predictive model output

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

Across the five creeks of the monitoring program missing EPT indicator taxa identified by AUSRIVAS Autumn edge and Combined season edge model output listed 16 taxa as missing. Identified were three mayfly larvae (Ephemeroptera), two stonefly larvae (Plecoptera) and 11 caddisfly larvae (Trichoptera). The same indicator taxa were identified by both of the aforementioned model outputs.

There were four families of EPT taxa found during the Autumn 2009 sampling period, of which only one was an EPT indicator taxa (Antipodoeciidae: Trichoptera) with a SIGNAL2 score of 8.

AUSRIVAS OE0 SIGNAL2

The addition of Autumn 2009 data to the Autumn edge AUSRIVAS OE0 SIGNAL2 model allowed for the Combined season edge output to be updated, as this is presented on a financial year basis.

The 2009 Autumn edge and 2008/09 combined season model does not include an average score for OE0 SIGNAL2 for Archers Creek. The model output described it as being *outside the experience of the model*. This also occurred in the Autumn 2008 output but at that time it still had an average score for the combined season output.

The AUSRIVAS OE0 SIGNAL2 Autumn 2009 average scores all fall within the previous range of stream health indicated for each creek. Shrimptons and Porters Creek slightly decreased whilst Buffalo and Terrys Creeks slightly increased compared to the previous Autumn 2008 scores (Figure 16). All five creeks have similar AUSRIVAS OE0 SIGNAL2 average scores for all seasons when compared to one another, all falling within each creeks respective stream health ranges (Figure 19).

The Autumn edge AUSRIVAS OE0 SIGNAL2 model output is similar through time and with seasons pooled compared to the Spring edge AUSRIVAS OE0 SIGNAL2 model output (Figure 15, Figure 16, Figure 18 and Figure 19).

The most recent AUSRIVAS OE0 SIGNAL2 combined season average scores fall within the previous range of stream health indicated for each creek. Only very slight changes in average scores occurred in the 2008/09 season compared to the 2007/08 season (Figure 17). Historically there has been very little variation between seasons for each creek and when comparing creeks from the combined season model output (Figure 17 and Figure 20).

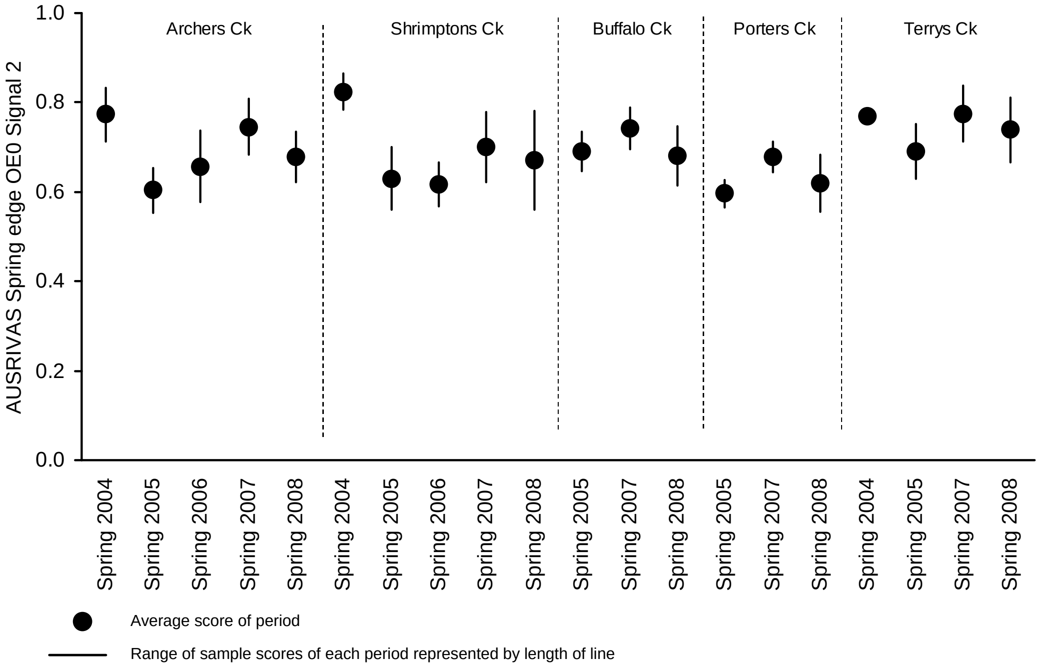


Figure 15 AUSRIVAS OE0 SIGNAL2 of all creeks from Spring edge model

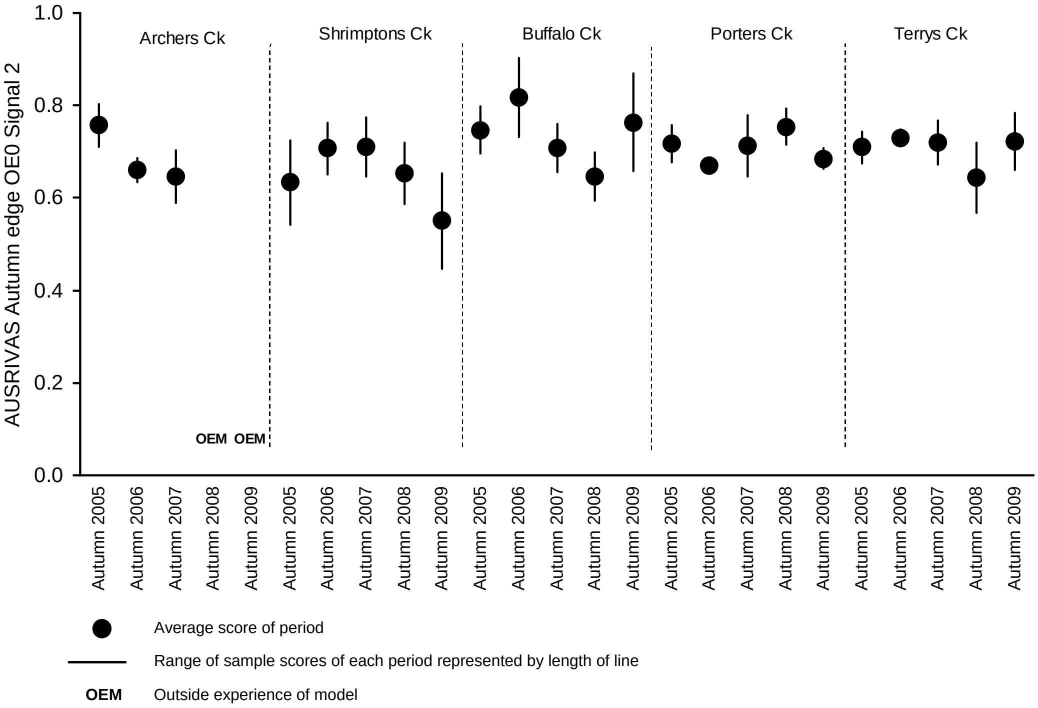


Figure 16 AUSRIVAS OE0 SIGNAL2 of all creeks from Autumn edge model

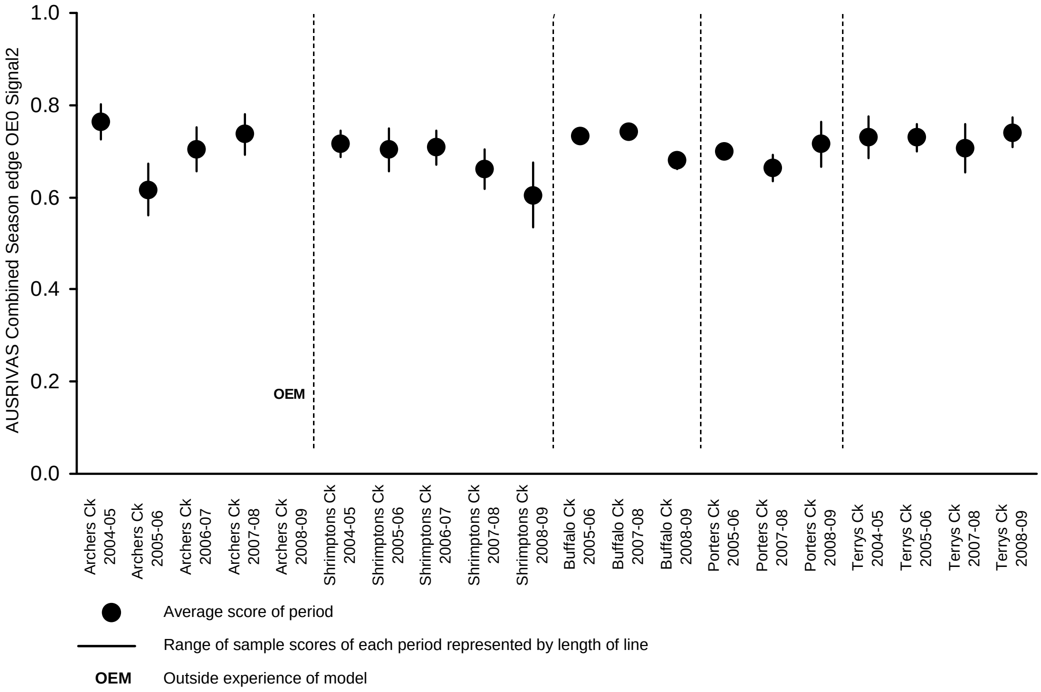


Figure 17 AUSRIVAS OE0 SIGNAL2 of all creeks from combined season edge model (with financial year data combined)

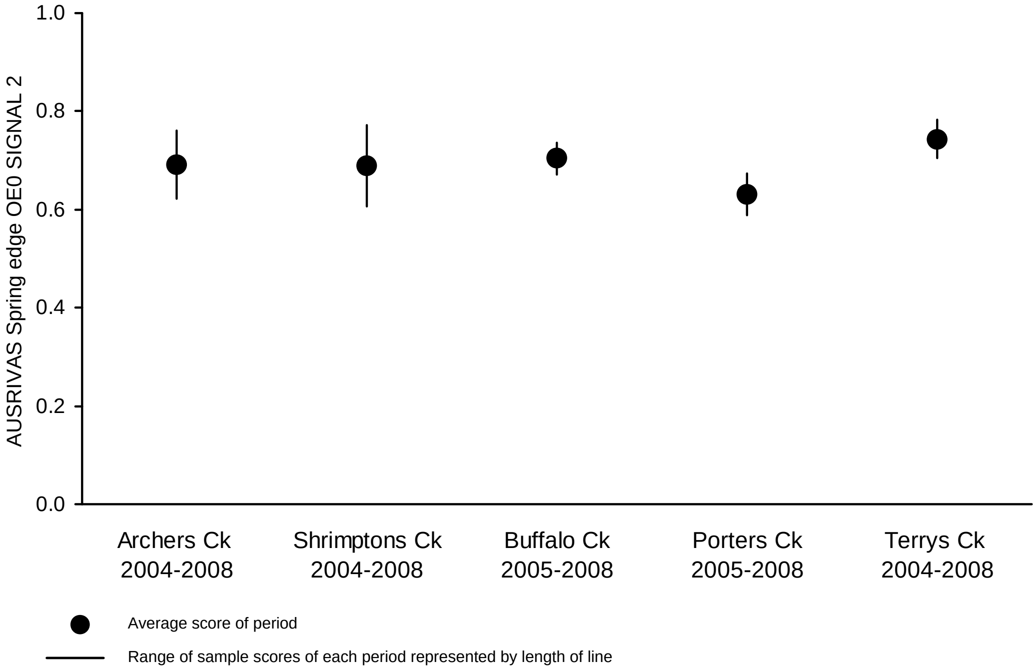


Figure 18 AUSRIVAS OE0 SIGNAL2 summary of all creeks from Spring edge model

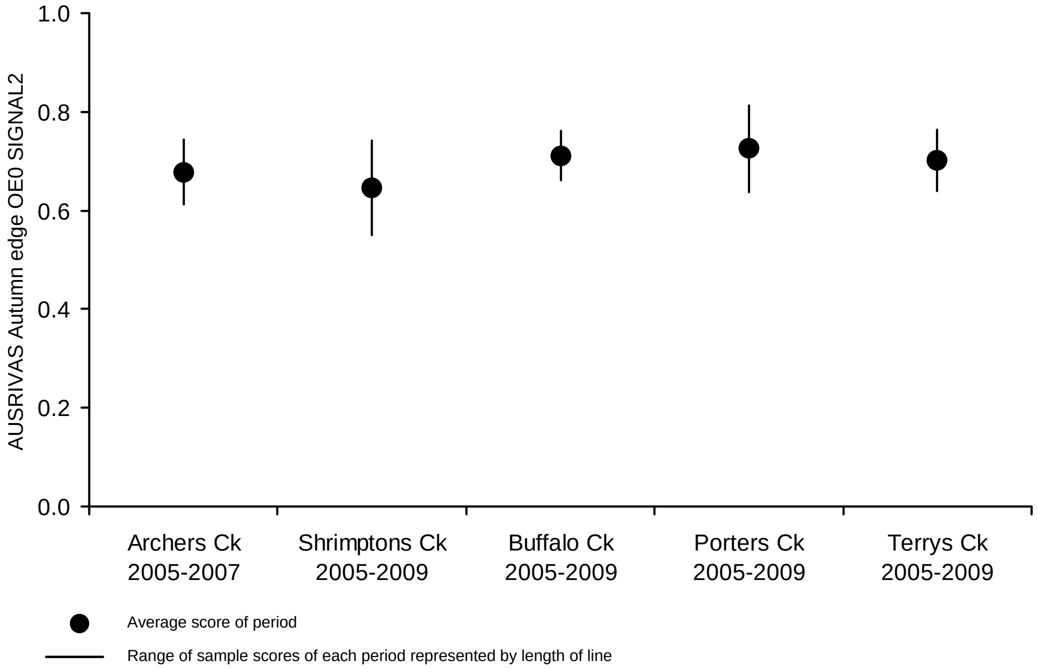


Figure 19 AUSRIVAS OE0 SIGNAL2 summary of all creeks from Autumn edge model

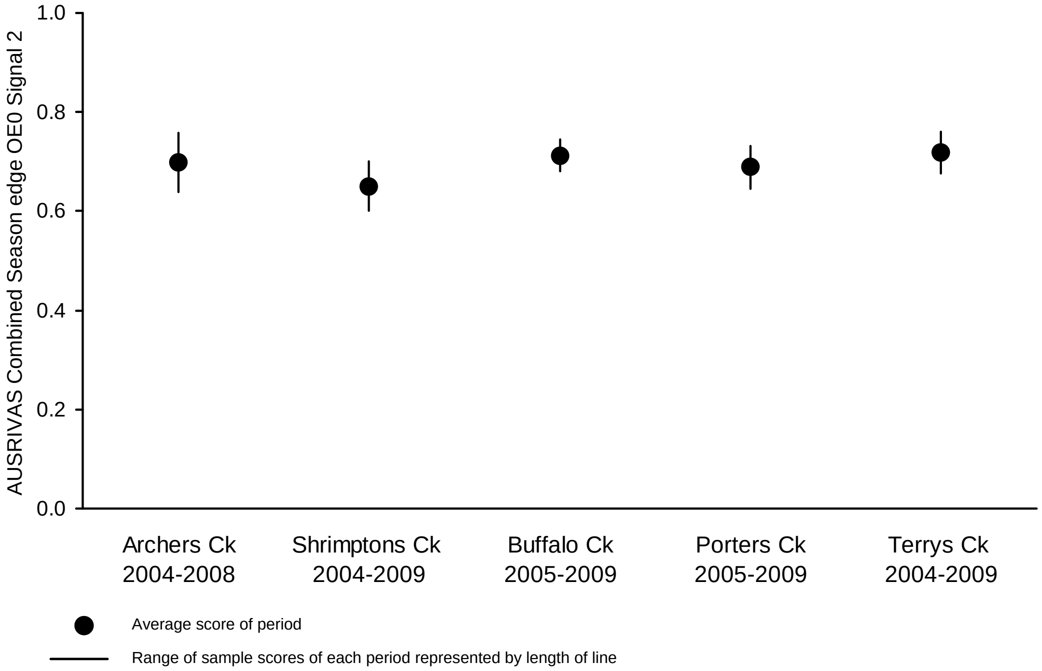


Figure 20 AUSRIVAS OE0 SIGNAL2 summary of all creeks from combined season edge model (with financial year data combined)

Multivariate Analyses

Ordination and SIMPROF test

In order to achieve suitable multivariate representations of data in 2 or 3 dimensions a strategy of pooling up replicates from the same season for each creek is used. This produces one data point per season per creek, it minimizes stress and gives a better measure of fit. This analysis strategy has been adopted for the ordination plot of all creeks (Figure 21). Presenting the data this way can be thought of as a way of reducing the noise of the replicate data from the somewhat patchy occurrence of macroinvertebrates at a stream site. In the Spring 2008 report the MDS ordination plot was presented in three dimensions, as the stress value of two dimension plot was high. The lower stress of the three dimension MDS ordination plot provided a better representation of community structure differences between the creeks. With the addition of Autumn 2009 data the three dimension ordination plot for all five creeks with replicates merged has again been used. The three dimension MDS ordination plot has also been used to show the community structure for Shrimptons and Terrys creeks. This has been implemented as the stress values for the two dimension ordination plots had high stress values (>0.2).

The SIMPROF test provides another way to view community structure differences and similarities between samples. SIMPROF results have been overlaid onto classification result output (dendrogram) with red lines indicating no difference between samples and the black line indicating a difference in community structure. The most notable SIMPROF test group consisted of six samples from Shrimptons Creek. One other notable test group consisted of five samples of Archers Creek, albeit with a Shrimptons Creek season and a higher similarity. Other groups are a mixture of samples from various creeks that have at about 60% similarity in composition of community structure of each sample (Figure 22).

The between season variability in community structure of Shrimptons Creek is displayed in Figure 21 and Figure 22. Autumn 2009 has a similar community structure to the previous sampling periods of Spring and Autumn 2008 which are distinctly different to Spring 2006 and 2007. This between season variability in community structure for Shrimptons Creek separates it for most samples from the other creeks.

The Archers, Buffalo and Porters creeks plots have indicated a similar variability in community structure through time. Terrys Creek has continued to show the least variability in community structure through time. Figure 22 shows that all seasons from Terrys Creek are in the last two groups of samples to be separated by SIMPROF (Figure 21 and Figure 22).

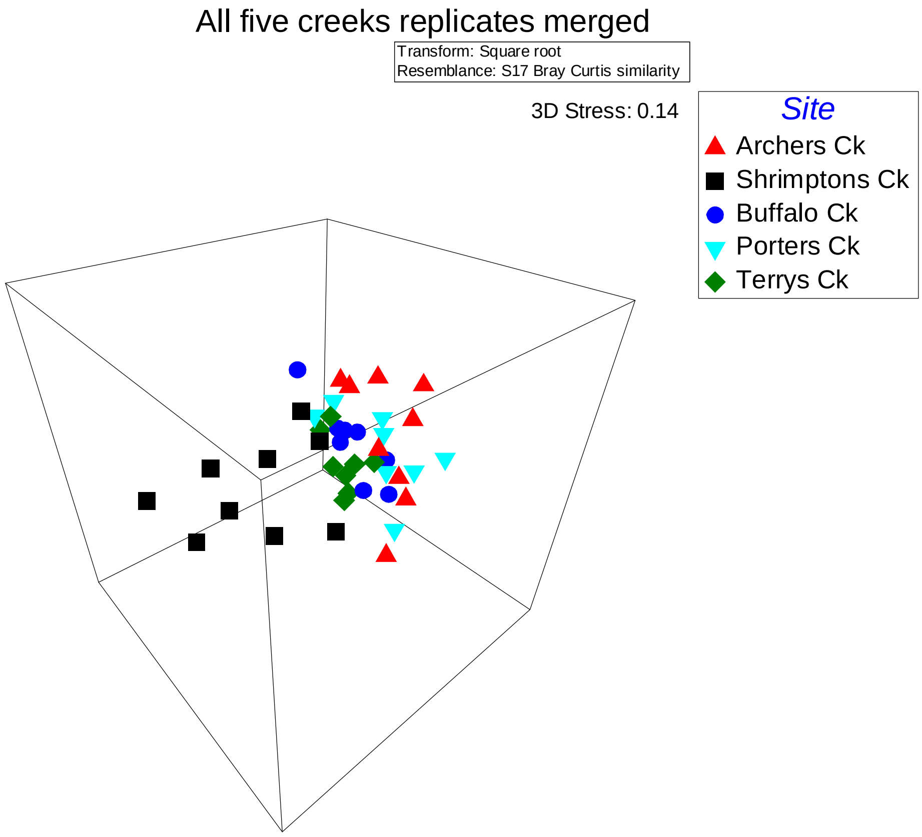


Figure 21 Plot of non-metric multidimensional scaling ordination results of 3-dimension analysis for 2005, 2006, 2007, 2008 and 2009 macroinvertebrate data of all creeks with each point of the same creek representing a different season

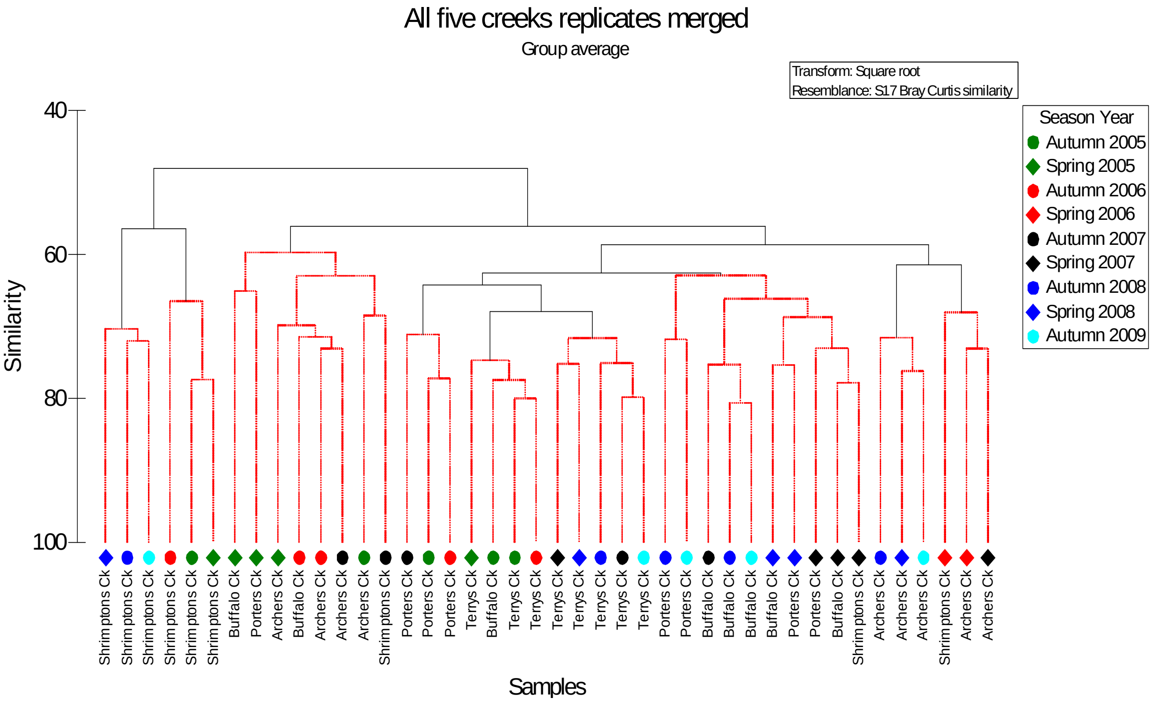


Figure 22 Dendrogram of all five creeks with SIMPROF test sample groups

Exploration of the similarity of Archers Creek macroinvertebrate community structure for 2005, 2006, 2007, 2008 and 2009 showed that samples from the same season are relatively similar (Figure 23). The SIMPROF test results indicated a general separation of autumn and spring samples, SIMPROF also highlighted one outlying sample from Autumn 2007 (Figure 24).

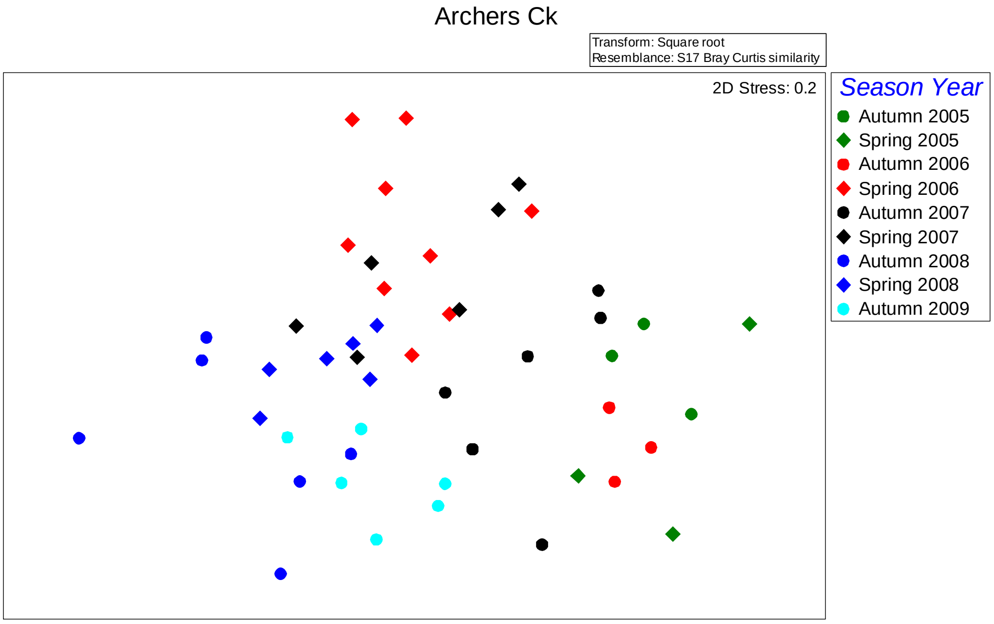


***Figure 23** Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 2008 and 2009 macroinvertebrate data of Archers Creek*

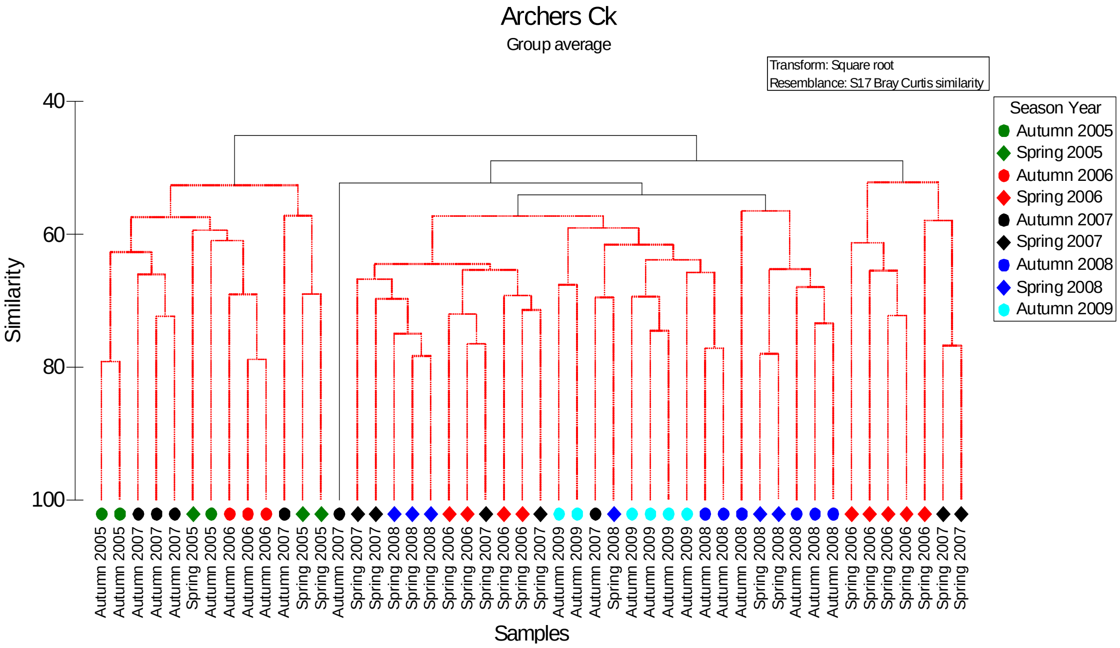


***Figure 24** Dendrogram of Archers Creek with SIMPROF test sample groups*

The SIMPROF test results for Shrimptons Creek indicated that samples from Spring 2006, Autumn 2007 and Spring 2007 are most taxonomically similar (Figure 26). This is also evident on the ordination plot (Figure 25). There are two outlying samples from Autumn 2008 and Autumn 2009 highlighted by the SIMPROF test and ordination plot (Figure 25 & Figure 26).

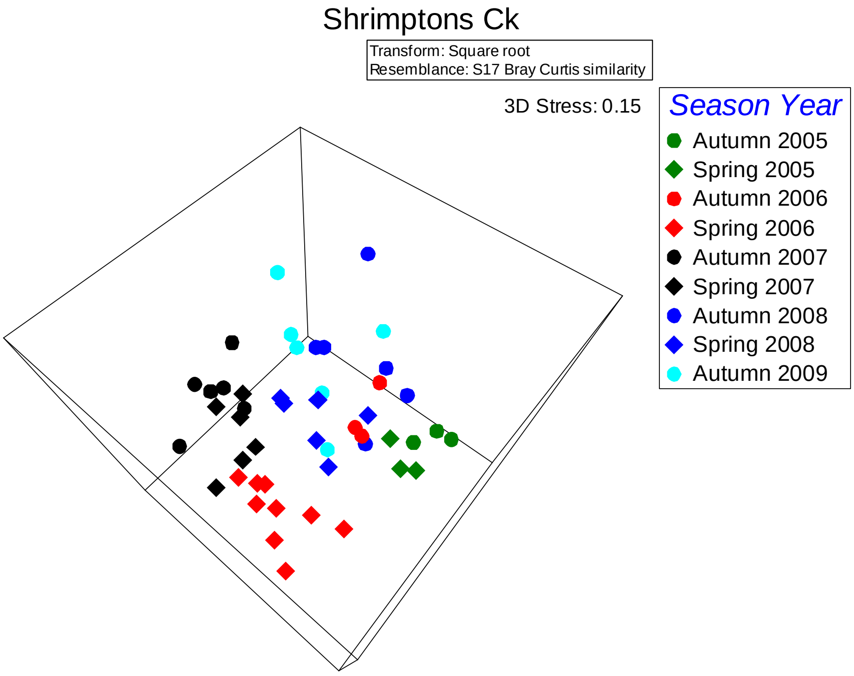


Figure 25 ***Plot of non-metric Multidimensional Scaling ordination results of 3 dimension analysis for 2005, 2006, 2007, 2008 and 2009 macroinvertebrate data of Shrimptons Creek***

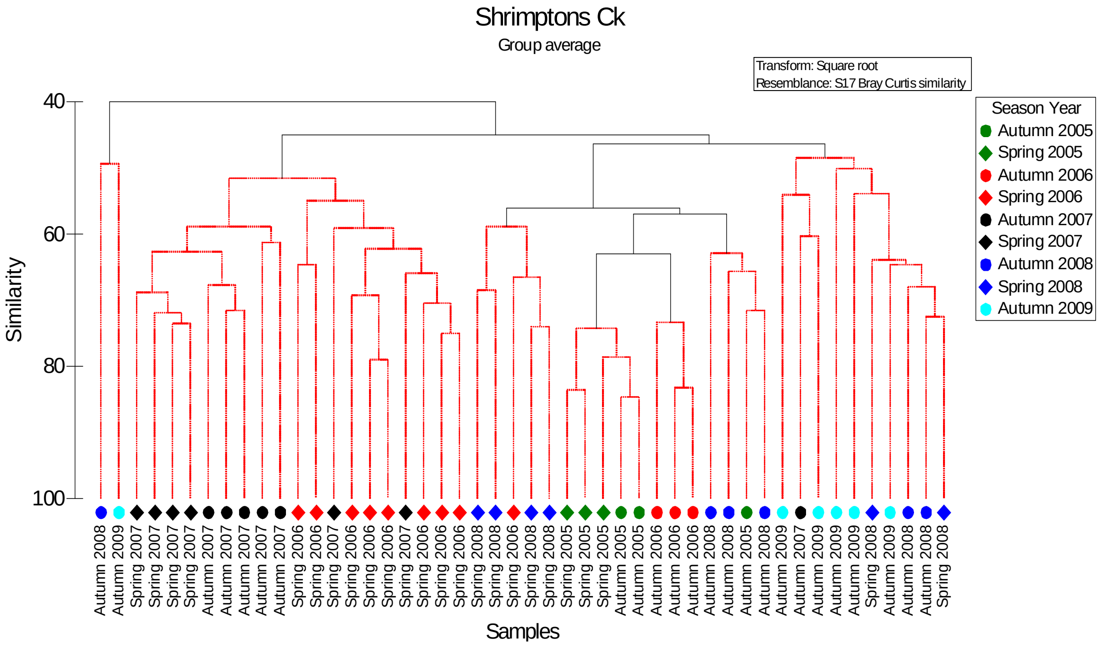


Figure 26 ***Dendrogram of Shrimptons Creek with SIMPROF test sample groups.***

The SIMPROF test results for Buffalo Creek indicated there are three main groups of samples. The largest of these groups contain Autumn 2007, 2008, and 2009 samples. There are also two outlying samples highlighted by SIMPROF from Autumn 2008 and 2009 (Figure 28). These groups are evident on the ordination plot (Figure 27).

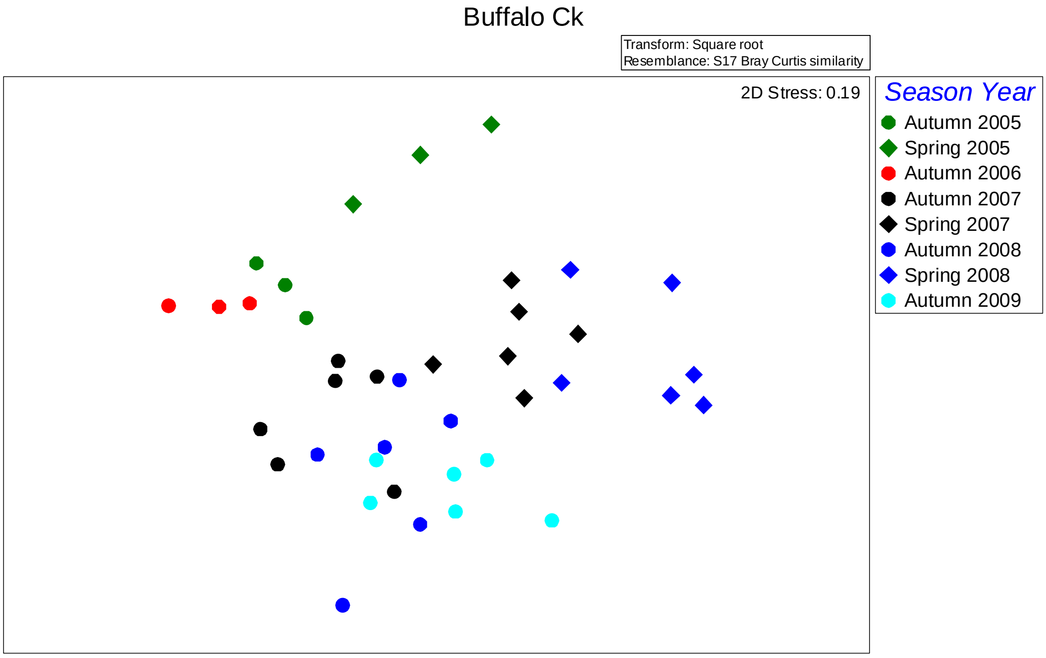


Figure 27 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007 2008 and 2009 macroinvertebrate data of Buffalo Creek***

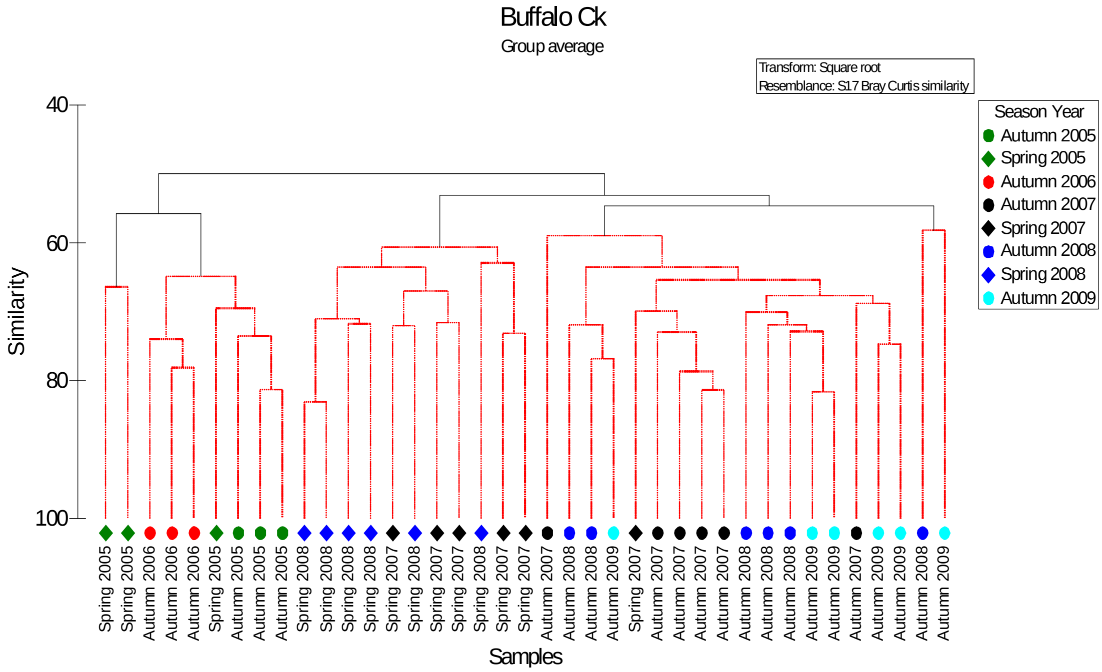


Figure 28 ***Dendrogram of Buffalo Creek with SIMPROF test sample groups***

The SIMPROF test results for Porters Creek indicated two outlying groups, one being two samples from Spring 2008 and one sample from Spring 2005. The remaining samples from Spring 2005 are also within one group. The remaining two groups are divided into samples from Spring 2007 and beyond, and samples from Autumn 2007 back to Autumn 2005. The divisions beyond this tend to be seasonal but aren't considered significant by the SIMPROF test. These grouping are also evident in the ordination plot (Figure 29 & Figure 30).

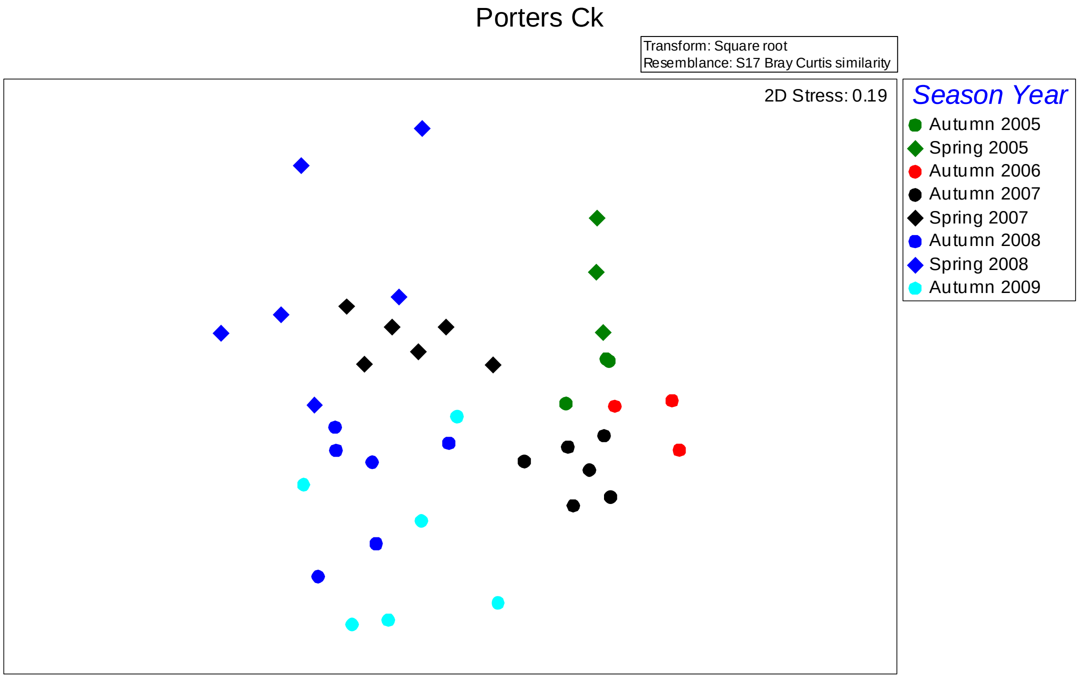


Figure 29 ***Plot of non-metric Multidimensional Scaling ordination results of dimensions 1 and 2 of 3-dimension analysis for 2005, 2006, 2007, 2008 and 2009 macroinvertebrate data of Porters Creek***

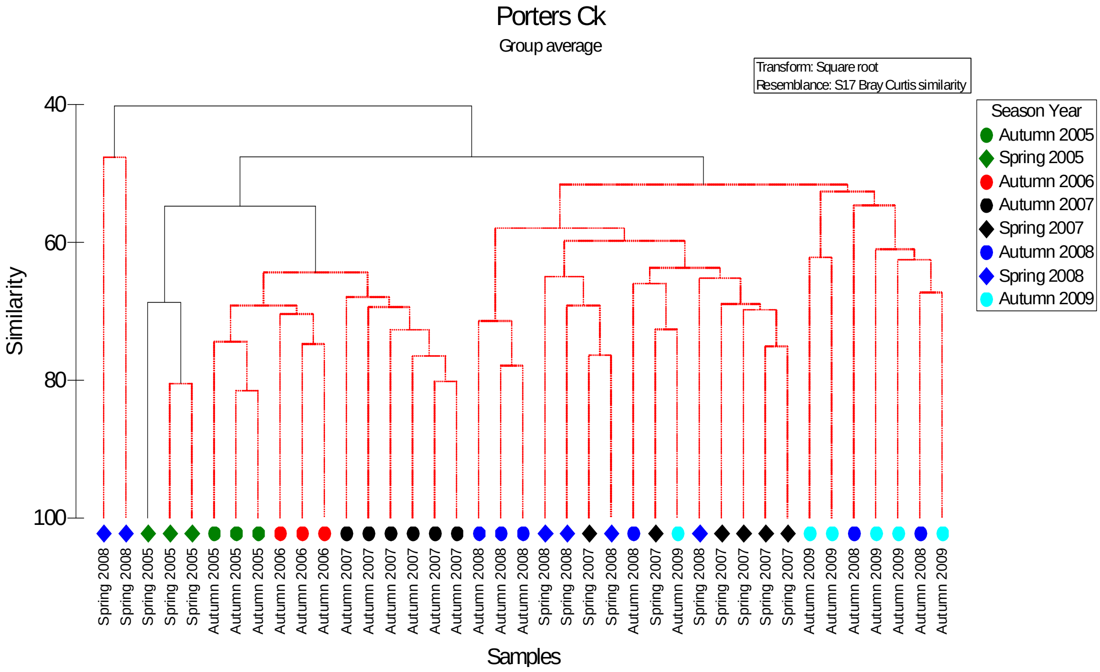


Figure 30 ***Dendrogram of Porters Creek with SIMPROF test sample groups***

SIMPROF highlighted an outlying sample from Spring 2008 in the first division. The next division separated four Autumn 2008 samples and two Autumn 2009 samples. These groupings are evident on the ordination plot (Figure 31 & Figure 32). The remaining samples formed the other groups of samples (Figure 32) these groups are evident on the ordination plot (Figure 31).

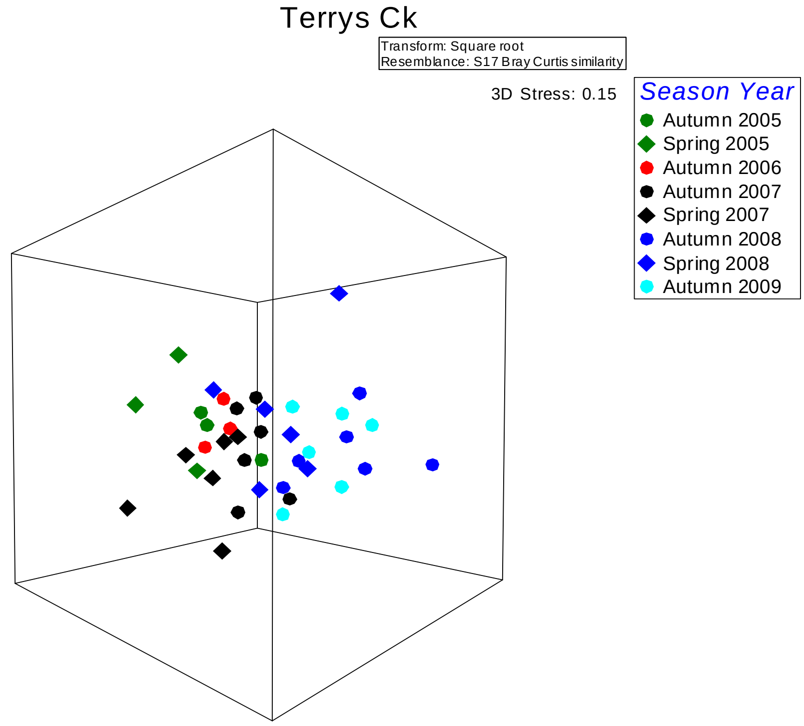


Figure 31 ***Plot of non-metric Multidimensional Scaling ordination results of 3 dimension analysis for 2005, 2006, 2007, 2008 and 2009 macroinvertebrate data of Terrys Creek***

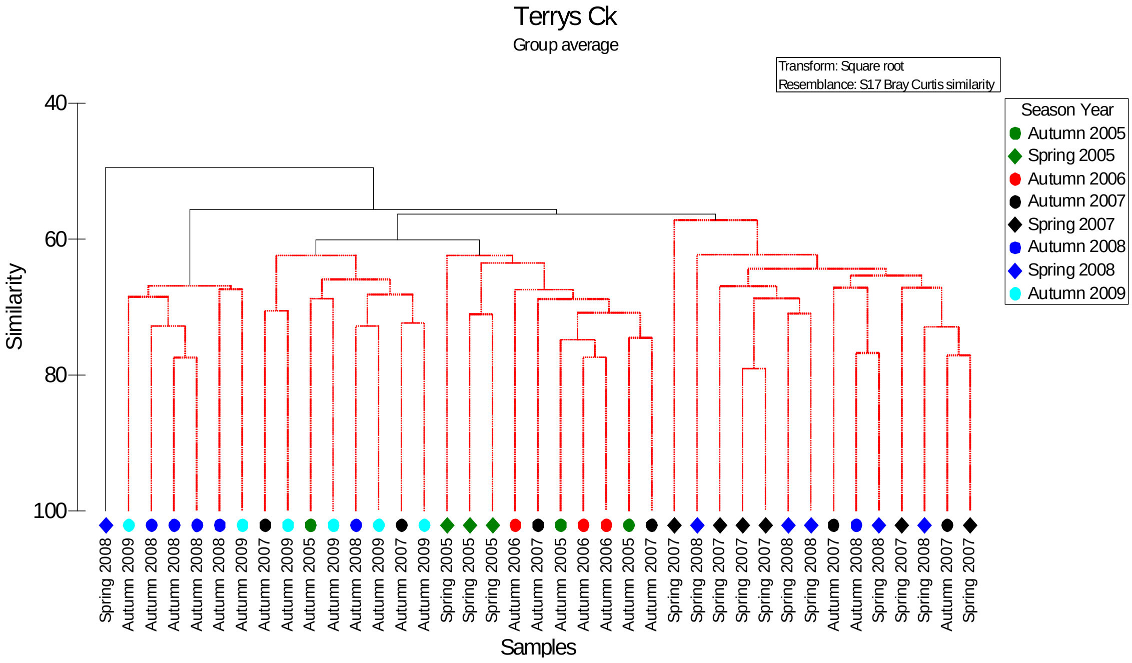


Figure 32 ***Dendrogram of Terrys Creek with SIMPROF test sample groups***

SIMPER

SIMPER when performed on all five creeks was based on merged replicates from the same season for each creek as per the combined creek ordination (Figure 21) and classification analysis. SIMPER results indicated Shrimptons Creek had the lowest overall (2005 to 2009) average similarity (58%). Archers Creek was slightly higher (62%), Buffalo and Porters creeks slightly higher again (64%), and finally Terrys Creek had the highest similarity (72%) (Appendix 5).

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

Table 12 Average dissimilarity between samples of creek comparisons

	Archers %	**Shrimptons %**	**Buffalo %**	**Porters %**
Shrimptons	49			
Buffalo	42	47		
Porters	44	51	38	
Terrys	43	47	37	38

SIMPER was then performed on each creek for samples shown in the MDS plots in the Classification and Ordination section of this report. Average similarity ranged from 57% to 77% (Table 12, Appendix 5).

From the SIMPER analysis a change in community composition was evident for Shrimptons Creek from the beginning of sampling in Autumn 2005 to the current season of Autumn 2009. This trend does not appear to be influenced by season. Tolerant non-insects dominated community structure in Shrimptons Creek with 5-6 taxa contributing roughly 90% of the community structure from Autumn 2005 to Autumn 2006. Community structure then became dominated by up to 10 taxa, with tolerant insects contributing significantly to the community structure from Spring 2006 to Spring 2007. Since Autumn 2008 the community structure has gone back to being dominated by tolerant non-insects with few dominant taxa.

Common non-insect community members included the introduced snail *Physa acuta* (Physidae), flatworms (Dugesiidae) and worms (Oligochaeta). The tolerant insects that were found were native non-biting midges (Chironominae), dragonflies (Megapodagrionidae, Coenagrionidae, Isostictidae, Hemicorduliidae) and back swimmers (Notonectidae).

The trend in community structure tends to be more seasonal for Archers Creek. During Spring tolerant insects contribute 40% and less to the overall community structure. During Autumn tolerant insects contribute 50% and more (Autumn 2006, 2008 and 2009 60%) to the overall community structure. The number of dominant taxa has remained stable for all seasons sampled, and generally only

3-4 taxa contribute 55-70% of the community structure for both Spring and Autumn.

Spring seasons for Buffalo, Porters and Terrys creeks the list of taxa that contributed to community structure is reduced and higher contributions from non-insects occur. This was particularly evident in Spring 2008, when 80% of Buffalo Creek's community structure was contributed by only three taxa. Autumn has generally had more consistent members of the respective communities through time, but with abundance differences evident between the seasons of Autumn 2005 to Autumn 2009. The exception being Autumn 2008 for Terrys Creek that had less dominant taxa, six compared with 13 to 14 for previous Autumn seasons (Appendix 5). The contribution to community structure of insects was generally greater than 60% in each of these creeks. In recent seasons however Porters Creek has shown a trend like that of Archers Creek in that higher contributions of few tolerant insect taxa is occurring in Autumn.

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

	Archers %	Shrimptons %	Buffalo %	Porters %	Terrys %
Autumn 2005	68	76	76	77	70
Spring 2005	59	77	67	73	65
Autumn 2006	72	77	75	72	73
Spring 2006	60	62	ns	ns	ns
Autumn 2007	57	60	70	71	66
Spring 2007	61	63	65	68	65
Autumn 2008	61	58	64	60	67
Spring 2008	70	63	66	52	62
Autumn 2009	64	48	69	58	63

ns = not sampled

BIOENV

The output of BIOENV routine is presented in Appendix 6. The correlation of extrinsic water quality and physical variables (Table 14) with intrinsic macroinvertebrate sample data of all five creeks for 2005 to 2009 was mild at 0.44. This is the strongest correlation that BIOENV has returned for all five creeks with replicates merged. BIOENV has returned stronger correlations since catchment stormwater delivery characteristics were first used in Autumn 2008. Investigation into the extrinsic variables identified in the best result correlation included total phosphorus, pH, rainfall, total length of pipe and ratio of number of outlets/catchment area. total length of pipe and ratio of number of outlets/catchment area were the only variables that were found in all of the 10 best correlations in the BIOENV output, rainfall was in 8 of the correlations.

BIOENV analysis of each individual creek for 2005 to 2009 produced to weak to moderate correlations of 0.35, 0.31, 0.37, 0.45 and 0.33 for Archers, Shrimptons, Buffalo, Porters and Terrys creeks respectively.

The combination of variables varied for all creeks but rainfall was consistently highlighted by BIOENV analysis in the best result. Terrys Creek had rainfall as the only variable in its strongest correlation. The exception was Archers Creek that was the only creek that did not have Rainfall as a variable in its best correlation. Rather oxidised nitrogen, turbidity and total dissolved solids provided the best correlation. Total dissolved solids were also present in all of the strongest correlations for Shrimptons and Porters Creeks. Rainfall however was highlighted in nearly all-top ten BIOENV results for each of the five creeks (Appendix 6).

The correlations for Autumn 2009 BIOENV output were all weaker compared to the Spring 2008 BIOENV for each respective creek except for Terrys Creek that got slightly stronger. The BIOENV output correlations dropped across all five creeks for Spring 2008 compared to Autumn 2008.

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

Table 14 Catchment storm water delivery characteristics for each creek

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

5 Discussion

5.1 Water quality

Water quality results, while not reflecting a sampling 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). Results of the Autumn 2009 water quality sampling for Shrimptons, Porters, Buffalo, Terrys and Archers creeks indicated that urban pollution transport is having a moderate impact on instream water quality; this impact was indicated by recorded low levels of dissolved oxygen and high levels of nutrients, especially nitrogen. This trend was also been observed in previous sampling events in 2004, 2005, 2006, 2007 and 2008 (Ecowise 2004, 2005a 2005b 2006, Sydney Water 2006, 2007a, 2007b, 2008a, 2008b). The additional water quality sampling did not indicate a clear point source of pollution for Shrimptons, Buffalo or Porters creeks. Pollutant concentrations were spatially highly variable indicating that they originate in varying locations over a constantly changing time period.

Weather conditions in the five months preceding Autumn 2009 sampling collection were characterised by relatively consistent moderate rain periods. This is in contrast with the previous Spring 2008 sampling period that saw below average rainfall in the preceding months before sampling.

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 is the result of 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 low dissolved oxygen levels during Autumn 2009 for Terrys, Shrimptons, Buffalo and Archers creeks are an area of concern. These sites are showing continually impacted dissolved oxygen concentrations during both periods of high and low rainfall. The Shrimptons Creek historical average dissolved oxygen concentration is the lowest of all five creeks indicating that there are problems with urban inputs along the whole length of the creek. These problems would be due to in-stream conditions caused by poor quality urban run-off transported through Shrimptons Creek. This problem is exacerbated during times of low rainfall and if dry conditions persist stream health will probably decline to the lower levels of Autumn 2005. The problem may also intensify after periods of moderate to heavy rainfall due to the increased load of decomposing organic matter from storm water runoff.

Dissolved oxygen levels at Porters Creek at both the core site and additional sites appeared to be at acceptable concentrations. Porters Creek has the healthiest historical average for dissolved oxygen of the five creeks and is probably related to more efficient run-off transport during both wet and dry periods. The Main Branch Channel in October 2008 recorded 147.4% saturation for dissolved oxygen, the first time that a sample has exceeded the upper limit for Dissolved Oxygen ANZECC (2000). This would most likely be explained by the presence of filamentous algae found to be growing on the concrete channel where water quality is sampled, in much greater densities and coverage than had previously been observed. The algae may also be improving the dissolved oxygen concentrations further downstream at the core Porters Creek site.

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 including urban runoff, presence of waterfowl and other wildlife, waste depots and illegal dumping of waste can influence faecal contamination of streams.

Faecal coliform concentrations were elevated above ANZECC (2000) recommended concentrations at both core and additional sites at various creeks in Autumn 2009. This is common after periods of moderate rainfall as seen in the February and March periods before sampling. Archers Creek and Shrimptons Creek Quarry Road display the most severely impacted faecal coliform concentrations. They can probably be linked to faecal contamination from urban runoff in storm water. The particularly high concentration at Quarry Road is likely to be the result of a sewer overflow into the storm water network during peak flows.

The turbidity levels for the five core sites and the additional sites were all compliant with ANZECC (2000) recommended concentrations. This indicates that the creek banks at Terrys, Shrimptons, Porters. Buffalo and Archers creeks are relatively stable and that silt loads within the catchments are being effectively controlled.

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, a lack of these elements is often the factor limiting growth of algae, bacteria and other plants. Increasing the readily available phosphorus and nitrogen loads in streams can lead to algal blooms and excessive plant growth. The elevated nitrogen levels as measured by total nitrogen, total kjeldahl nitrogen and total oxidised nitrogen found in the core and additional sites at all five creeks during Autumn 2009 were most likely from urban catchment runoff and decomposing organic matter as well as low dissolved oxygen levels, this is known to be a significant contributor to increased readily available nutrients from sediments via chemical synthesis.

The elevated levels of all nutrients at Archers Creek during March 2009 indicate that a particular activity in the upper reaches of the catchment had a significant impact on nutrient loads into the creek. These concentrations are the highest recorded nutrient results at this site for the strategy with accumulated data from Spring 2004 to Autumn 2009. Some recovery from this impact was observed in the April 2009 sampling occasion, although total nitrogen and total oxidised nitrogen still remained elevated above historical averages. Shrimptons Creek Quarry Road also displayed similar results during the March 2009 sampling occasion. Elevated nutrient levels are probably directly related to the extremely high levels of faecal coliforms that may be the result of a sewer overflow during a period of peak flow. This is further supported by the ammonia results.

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

Laboratory methods for ammonia record the nitrogen content from the ammonium (associated ionic form) ions NH4+. This ion forms compounds with other particles dissolved within the water column. It is harmless to plants and animals within the specified concentration, pH and temperature range. ANZECC (2000) has determined this to be 20 µg/L for the protection of aquatic life in lowland streams with a pH of 8 and temperature of 20^{0}C. Ammonia (NH3) is a toxic by product of NH4+ that exists as a gas of which the N content is not measured during the routine laboratory analysis. With increasing temperature and pH the % of NH3 against NH4+ increases exponentially and it is this compound that is detrimental to aquatic life. ANZECC (2000) does not measure this or provide guidelines on this form but it does determine the NH4+ concentrations that are dangerously high and most likely to produce the toxic NH3 compound, and it provides guidelines on this.

Ammonium results for March 2009 were elevated to the highest levels ever recorded for Shrimptons Creek Quarry Road and Archers Creek. The elevated levels of ammonium in this creek indicate that under less favourable conditions the ammonium (NH4+) ion will be converted to the potentially toxic ammonia (NH3) compound and compromise the health of the aquatic ecosystem. Full recovery to satisfactory levels had occurred by April 2009. The core and additional sites in Porters Creek have historical and current high levels of ammonium often exceeding ANZECC (2000) recommended levels during 2005, 2006, 2007 2008 and 2009. Spatial reductions upstream may suggest that the City of Ryde Waste Depot contributes to the continually higher ammonium concentrations found at the most downstream core site.

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

Total dissolved solids concentrations continued to be elevated above historical averages at Buffalo Creek core and additional sites during Autumn 2009. This could be linked to the urban development in the headwaters of the creek. It is possible that contaminants associated with TDS may be impacting on aquatic stream life.

5.2 Macroinvertebrates

Results for the Autumn 2009 session of the Biological and Chemical Water Quality Monitoring Strategy of Ryde City Council indicate that Archers, Shrimptons, Buffalo, Porters and Terrys creeks had impaired macroinvertebrate communities. Similar results have been recorded from Spring 2004 to Spring 2008.

ANZECC (2000) indicates that adequate baseline data is required to determine an acceptable level of change in an environment. Only then can informed management judgments be made that take account of natural variability in an indicator, in this case macroinvertebrates. ANZECC (2000) also suggests three to five years of data be gathered from control or reference locations. The City of Ryde Monitoring Strategy uses comparable data from all five creeks that each have their own natural variations in macroinvertebrate assemblages. The Sydney specific SIGNAL-SF index and the NSW AUSRIVAS predictive models provide this data by the statistically defined 10th percentile of mean reference condition values. The range of each measure of stream health has been plotted in this report with a +/-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 for management tracking and decision making. To date, there have been eight seasons of comparable data from this strategy since sampling began in Spring 2004. The inclusion of data from seasons in years of average or above rainfall would provide a more complete baseline for management decisions.

A total of 1,778 macroinverterbates were collected during the Autumn 2009 sampling season. This total is similar to counts of 1,787 for Spring 2008 and 1,811 for Autumn 2008. These counts are in contrast to totals of 2,635 for Autumn 2007 and 2,490 for Spring 2007.The previous two sampling seasons also saw a drop saw a drop of roughly 10 taxa from numbers of macroinvertebrates collected in earlier sampling seasons. It is difficult and probably misconceived to try and link this to any water quality or other in-stream factors. The reduced numbers in 2008 and 2009 may in fact reflect environmental cues that influence the development of macroinvertebrate taxa with either the taxa not being present in the water at the time of sampling or the cohort (age class) being too small to be retained by 0.25 mm mesh of the net.

Sensitive taxa, as measured by EPT richness were present in low numbers in Archers, Buffalo, Porters and Terrys Creeks in Autumn 2009. Archers and Porters Creeks had the highest presence of EPT taxa yet neither averaged two or more taxa. Shrimptons Creek had no EPT taxa present. This creek has always performed poorly in this measure, particularly during Autumn each year, when only one individual EPT specimen has ever been collected. While only one family of EPT taxa was collected in Spring 2008, Autumn 2009 saw four families of EPT taxa collected. One replicate from Porters Creek in the March round of sampling had all four of these taxa present. Of the EPT taxa collected in Autumn 2009 only one taxa, Antipodoecidae is an EPT indicator taxa from AUSRIVAS predictive model with a SIGNAL2 score greater than 6.

Generally, EPT taxa collected in the City of Ryde study creeks are in low abundances and are found sporadically, and have typically been tolerant EPT taxa. Because of these factors, EPT richness as a measure is limited in its ability to suggest any future negative impacts on stream health. In the Spring 2007 report it was suggested the return to average or above average rainfall conditions might influence the presence of EPT taxa. Average conditions returned for the Autumn 2008 and 2009 sampling seasons but were drier before the Spring 2008 season. Considering these fluctuations and the relatively low occurrence of EPT taxa, a period of more prolonged rainfall may be required to see an improvement. However EPT may be able to indicate positive community structure changes. Therefore 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.

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.

Archers Creek SIGNAL-SF average score for Autumn 2009 was very similar to the previous Spring 2008 score. For each season since Spring 2004, Archers Creek has indicated a mild trend of higher SIGNAL-SF scores in Autumn compared to the previous Spring. AUSRIVAS OE50 output had also indicated higher scores in Autumn than for Spring, however this was apparent for all creeks. The Autumn 2009 SIGNAL-SF score doesn’t fit this trend. Due to the AUSRIVAS model output stating that the Archers Creek data was *outside the experience of the model* a comparison cannot be made with AUSRIVAS results for Autumn 2009 or the updated combined season output. SIGNAL-SF and AUSRIVAS OE50 averages for all sampling seasons indicate that Archers Creek has slightly better stream health than the other five creeks.

As mentioned AUSRIVAS predictive model OE50 and OE0 SIGNAL 2 output did not include a result for Archers Creek for Autumn 2009 or the combined 2008/2009 season. The output described it as being outside the experience of the model. This means that the combination of the physical and biological data was not typical of reference material used by the AUSRIVAS Autumn eastern edge model. Changes to the stream channel of Archers Creek combined with few AUSRIVAS reference sites situated in the Sydney region may explain the result.

Shrimptons Creek's SIGNAL-SF average score for Autumn 2009 was very similar to the Spring 2008 and Autumn 2008 average scores. The AUSRIVAS OE50 Autumn edge output had a similar stream health for Autumn 2008 and Autumn 2009. Recent SIGNAL-SF and AUSRIVAS OE50 edge results indicate stable stream health for Shrimptons Creek, which has shown a high variability over time. These recent results come after both analysis tools indicated a peak in stream health from Spring 2006 to Spring 2007. OE0 SIGNAL2 and AUSRIVAS OE50 combined season outputs have not shown this change in stream health over time. SIGNAL-SF and AUSRIVAS OE50 averages for all seasons sampled indicate that Shrimptons Creek as having the slightly poorer stream health of the five creeks.

Buffalo Creek SIGNAL-SF average score for Autumn 2009 was higher than the previous Spring 2008 score. The previous Spring 2008 SIGNAL-SF score dropped significantly from the previous Autumn 2008 score. AUSRIVAS OE50 output also indicated a drop in stream health for Spring 2008 and placed Buffalo Creek in the Extremely Impaired band (Band D), recording the lowest Spring score historically of any creek. The AUSRIVAS OE50 Autumn 2009 score was similar to the Autumn 2008 score. These results indicate that an impact causing stream health to drop occurred in the time before Spring 2008 sampling. The apparent increase in stream health indicates that this impact may no longer be affecting stream health in Buffalo Creek, however more data is needed to confirm this.

Porters Creek SIGNAL-SF average score was higher in Autumn 2009 than the previous Spring 2008 season. Porters Creek has shown a similar seasonal trend to that of Archers Creek (except for Archers Autumn 2009) that is, higher scores in Autumn compared to lower scores in the Spring. Although with missing data points more seasonal sampling would be required before and established trend could be suggested. As stated before AUSRIVAS OE50 had higher stream health scores for Autumn and lower scores for Spring, but this trend was true for all five Creeks.

The SIGNAL-SF average scores, AUSRIVAS OE0 SIGNAL2 model output and the AUSRIVAS OE50 Autumn edge and combined season model outputs all indicate very little variation over time for Terrys Creek. Autumn 2009 scores fitted within previously sampled seasons. There had been a very gradual and minimal drop in stream health since the 2006 sampling seasons, but the Autumn 2009 results for all univariate analyses indicate a slight increase in stream health.

AUSRIVAS OE0 SIGNAL 2 results indicated very little variation over time for each creek for both Autumn and Spring and the combined season model. It also showed little variation between creeks both seasonally and for all seasons sampled.

The slight differences in patterns presented by SIGNAL-SF, AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2 measures partially relate to the abundance and tolerance component involved in the calculation of SIGNAL-SF scores, versus presence absence component used in the calculation of AUSRIVAS OE50 and AUSRIVAS OE0 SIGNAL2. Another source of the slight differences between these two analysis tools may arise from direct measurement and measurement via comparison to reference site groups of the AUSRIVAS predictive models.

Despite these slight differences and with the EPT richness index, results from all univariate analysis tools indicate impaired stream health in the five creeks studied under the monitoring strategy.

A limitation of AUSRIVAS models is the difference in band threshold values for Autumn, Spring, and combined season 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. Coysh et al. (2000) indicates mixing assessments based on different season models should be discouraged. Hence, Autumn, Spring and Combined Autumn/Spring model results were presented separately for AUSRIVAS output. SIGNAL-SF (Chessman et al., 2007) does not have this seasonal limitation, and perhaps trends are more easily identified from this tool.

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

Multivariate analyses indicated biological signature or community (assemblage) structure of Shrimptons Creek has been more variable through time than the community structure of the other four creeks. Shrimptons Creek has a similarity of 58% between replicates through time. Most of the univariate analyses have highlighted this variation and.Terrys Creek has shown the least amount of variability through time. SIMPER results showed that Terrys Creek has a 72% similarity between replicates through time. The multivariate analyses and the univariate analyses highlight that Terrys Creek has the most stable macroinvertebrate community structure and stream health of the five creeks investigated.

Multivariate SIMPER results indicated that Buffalo, Porters and Terrys creeks have generally had a community structure resembling one another with mild shifts relating to seasonal change. Archers Creek has had similar community structure to the aforementioned creeks but with seasonal differences. The seasonal trend in Archers Creek was also apparent in the univariate tools SIGNAL-SF and AUSRIVAS OE50 with stream health in Spring generally poorer than in Autumn. The seasonal change in Porters Creek was also indicated by the multivariate and univariate analyses mentioned for Archers Creek. However, more data is needed before an established trend for Porters Creek can be suggested. The community structure of Shrimptons Creek has, at times been quite different. It has often been dominated by tolerant non-insect taxa and has not appeared to experienced seasonal differences.

Buffalo Creek SIMPER results for Spring 2008 indicated that community structure was dominated by only three taxa. There was an 80% contribution from tolerant taxa Aquatic Snails (Physidae and Hydrobiidae) and the non-biting midge (Chironominae). This change in community structure coincided with the lowest to date SIGNAL-SF average score while the AUSRIVAS OE50 output dropped to the ‘Extremely Impaired’ band (Band D) for the first time.. In the previous Autumn 2008 sampling season elevated levels of turbidity were present. Spring 2008 saw a build-up of sediment at the core Buffalo Creek site. It was suggested in the Spring 2008 report that this change was due to the loss of some taxa due to a smothering effect of fine sediment on in stream habitats caused by run-off from development in the upper catchment. This smothering effect has been linked to the loss of certain taxa in streams that has had an influx of fine sediment within forestry areas (Vuori & Joensuu, 1996; Death et al., 2003), this smothering coincided with the dominance of new taxa. Death et al. (2003) found that dominant sensitive mayfly taxa were lost and that tolerant (including Chironomidae and Hydrobiidae) taxa became dominant when elevated levels of fine sediment were introduced to streams.

It was suggested that the apparent loss of taxa and drop in stream health in Buffalo Creek was potentially reversible if the source of sediment can be controlled or removed. SIMPER results for Buffalo Creek in Autumn 2009 indicated that nine taxa were contributing to 80% of the community structure. The SIGNAL-SF average score increased and EPT taxa slightly increased. Water quality results showed that turbidity levels were not elevated. This potentially means that the sediment related impact is no longer affecting Buffalo Creek. If this is correct than it was a short term impact. Wood & Armitage (1997) suggested that short term increases in fine sediment due to human disturbances like construction developments can lead to a rapid recovery. Further biological sampling of Buffalo Creek is needed before a recovery can be substantiated. This will allow for additional data for both multivariate and univariate analyses, and particularly AUSRIVAS for comparing spring seasons and combined seasons.

Chessman et al. (2006) determined twice as many taxa appeared to favour sites in good geomorphic condition as those favouring poor sites. Chessman et al. (2006) also indicated that 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). The low occurrences of Mayflies and Caddisflies highlighted by the EPT data as well as beetles, yet with the abundance of introduced taxa in the City of Ryde creeks suggests their poor condition.

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

The attempt to link water quality patterns to macroinvertebrate patterns using the multivariate BIOENV routine produced weak to moderate correlations. The strongest correlation was a moderate result of 0.45 for Porters Creek. Rainfall and total dissolved solids were the variables that appeared in the strongest correlations for the individual creeks.

Rainfall was a variable that has continually been included in the strongest correlations in the BIOENV analysis, with the exception of Spring 2008. This was possibly due to the low rainfall leading up this period. Autumn 2009 it was present in the strongest correlation and a majority of the remaining correlations. This coincides with the catchment storm water delivery characteristics total length of pipe and the ratio of number of outlets/catchment area being included in all 10 of the strongest correlations. This outcome suggests catchment pollution transport to the stream is a contributing factor influencing in-stream macroinvertebrate community structure.

Rainfall has been suggested as one of the main drivers limiting the stream health of these urban creeks, not the sole driver. Each creek would have its own problem areas regarding pollution; Porters Creek with ammonia and Shrimptons Creek with sewage related faecals, for instance. It is however the rainfall events that, for the most part, introduce these pollutants into the creek. Controlling the run-off particularly from impervious surfaces may hold the key to improving stream health.

The BIOENV correlation for all five creeks, while only mild was stronger than Spring 2008. However four of the five creeks returned weaker correlations than in Spring 2008. This suggests that the physico-chemical variables measured to date under the strategy do not appear to be all of the drivers for recorded shifts in macroinvertebrate community structure. As such, efforts to improve water quality should not be solely concentrated on these variables measured to date.

It is with this in mind that the relevance of the macroinverterbate communities is highlighted. The macroinverterbates for the most part live in or on the water throughout most of their life stages, this can be weeks or years. The macroinvertebrates are affected by all of the extremes from human and environmental impacts. The tolerances of the animals over time will determine the community assemblages, and give a good indication of stream health.

Research conducted in the greater Melbourne area that looked at water quality, epilithic diatoms, benthic algae and macroinvertebrate indicators suggested that minimisation of directly piped stormwater drainage connection of impervious surfaces was 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 was 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), this is provided that 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 that community composition was strongly explained by the gradient of urban density, observing 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 to date in the City of Ryde creeks may suggest a greater than 20% connection of impervious surfaces to Archers, Shrimptons, Buffalo, Porters and Terrys creeks. Inclusion of data from a number of above average rainfall periods is required before comment can be made with on the 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 in the City of Ryde, policies that facilitate infiltration, evaporation and 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.

Surrogate measures for effective imperviousness were introduced to the BIOENV analysis routine. They suggested an impact on in-stream macroinvertebrate community structure from catchment pollution transported to the stream by efficient storm water delivery systems from the impervious surfaces of each catchment. These surrogates were used to minimise council expenditure on calculating effective imperviousness as defined under the abovementioned Melbourne research. Stronger correlations from the BIOENV routine may have been achieved if effective imperviousness had been calculated and was available for input into the BIOENV analysis. Expenditure on calculation of effective imperviousness is not considered warranted given results obtained from the surrogates. Therfore the Melbourne work provides a solid basis for council decision-making under the Biological and Chemical Water Quality Monitoring Strategy.

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

6 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, Autumn and Spring 2008 and Autumn 2009 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, accessibility 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 facilitates interpretation of collected data.
- Provide for a series of options for identification of key indicator taxa to family and or morphospecies;
  - This is provided by EPT indicator taxa from AUSRIVAS predicted model output. SIGNAL-SF grades could also be used to assess key indicator taxa. With currently only two EPT indicator taxa recorded to date no advantage is afforded by SIGNAL-SF at this stage.
- Identify a standard suite of analyses to determine status and trends in water quality including calculation of the AUSRIVAS index;
  - Suitable indices such as SIGNAL SF to assess water quality status, including calculation of the Observed/Expected (OE50 and OE0 SIGNAL2) ratios from the respective AUSRIVAS predictive models for autumn, spring, and combined seasons were evaluated in Spring 2006 with subsequent recommendation made and these have been implemented in Autumn and Spring 2007, Autumn and Spring 2008 and Autumn 2009 reports. Multivariate statistical analysis techniques have also been incorporated into Spring 2006 to the current Autumn 2009 reports. A change was made to the routine used to assess water quality and macroinvertebrates 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. In the Spring 2008 the SIMPROF test was added, due to recent advances in multivariate statistical software.
- Provide the basis for an appraisal of the capacity of a standard monitoring strategy to be integrated into a community monitoring program eg. Streamwatch.

  - Suggestions were put forward in the Spring 2006 and Autumn 2007 reports for use of SIGNAL2 in a format that could be calculated by community groups without access to the AUSRIVAS predictive models. In the 2007 report, calibration was made for boundary points of water quality status so community groups could use this analysis in the City of Ryde area. Standard collection methods would need to be used and suitable quality control of data would need to be implemented to provide comparability of data through time.
- Provide the foundation to augment the Streamwatch capacity within the City of Ryde including options for improved education awareness of water quality issues within schools and community groups.
  - As above.
- Provide information and direction on potential infrastructural works to complement water quality monitoring and improve overall creek health.
  - The consolidation of available comparable data that has occurred and additional sampling will allow capture of variation through time and under different weather conditions in each of the five study streams. Continued average rainfall conditions or better would be advantageous to allow capture of variation in community structure and water quality under wetter conditions. Understanding variation between Autumn and Spring and under different weather conditions will provide better base line data to assess changes in community structure that may result from future City of Ryde management actions.

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Appendix 1 Quality assurance

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

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

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

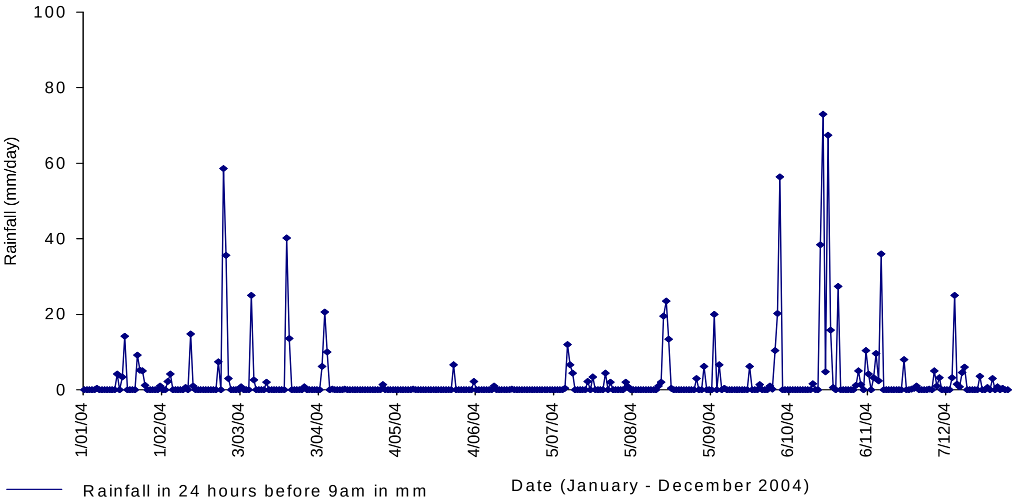
Appendix 2 Water quality results

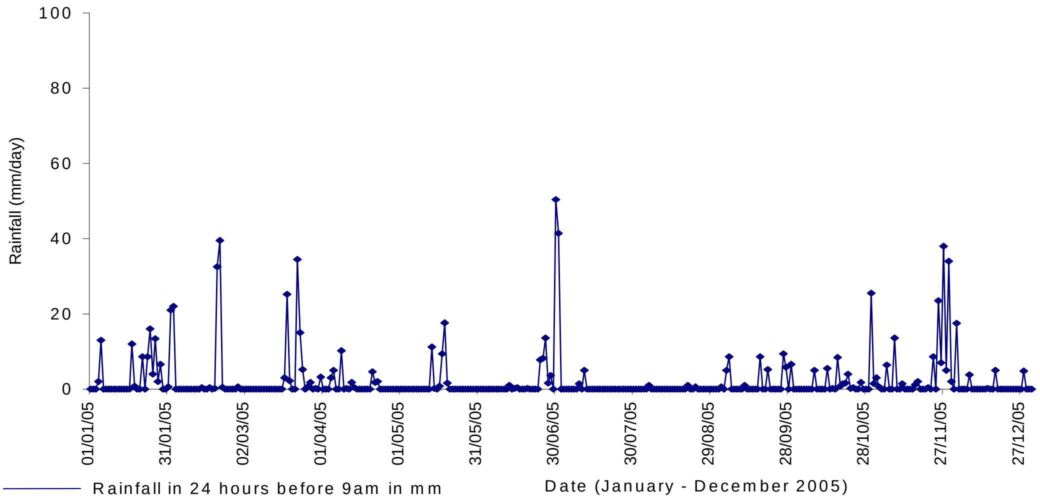
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature ^{O}C
Terrys Ck	Site 1	autumn 2009	19/3/09	67	10	260	25	350	610	72	2.9	525	282	7.6	7.2	18.0
Shrimptons Ck	Site 2	autumn 2009	19/3/09	1200	<10	90	43	510	600	70.1	2.8	377	220	7.3	0.2	19.4
Porters Ck	Site 3	autumn 2009	19/3/09	3000	820	1290	27	1490	2780	106	2.9	487	266	7.8	8.3	20.4
Buffalo Ck	Site 4	autumn 2009	19/3/09	240	20	580	31	520	1100	89	7.0	886	490	7.3	4.7	17.8
Archers Ck	Site 5	autumn 2009	19/3/09	4800	1220	1380	171	1760	3140	78.5	2.2	517	278	7.4	5.8	17.8
Terrys Ck	Site 1	autumn 2009	1/5/2009	140	<10	180	20	240	420	64.8	2.1	518	300	7.6	7.9	12.5
Shrimptons Ck	Site 2	autumn 2009	1/5/2009	350	<10	140	34	340	480	81.5	2.1	481	289	7.5	7.4	14.5
Porters Ck	Site 3	autumn 2009	1/5/2009	~190	860	1350	21	1010	2360	86.3	4.0	449	268	7.8	9.4	16
Buffalo Ck	Site 4	autumn 2009	1/5/2009	92	<10	330	20	310	640	72.2	4.3	708	408	7.5	7.8	14
Archers Ck	Site 5	autumn 2009	1/5/2009	~1700	<10	860	31	270	1130	67.3	2.7	472	269	7.8	8.5	12.8
Terrys Ck	Site 1	spring 2008	16/9/08	~820	10	120	35	370	490	41.5	11.5	254	149	7.2	7.75	14.6
Shrimptons Ck	Site 2	spring 2008	16/9/08	240	20	250	54	440	690	51	8.85	278	155	7.1	3.8	16.1
Porters Ck	Site 3	spring 2008	16/9/08	260	4000	1660	24	4520	6180	130	5.46	611	336	7.7	9.6	14.7
Buffalo Ck	Site 4	spring 2008	16/9/08	820	10	450	42	400	850	79.5	10.8	524	293	7.34	7.21	14.9
Archers Ck	Site 5	spring 2008	16/9/08	270	10	670	19	350	1020	82.5	2.71	555	311	7.67	10.4	13.7
Terrys Ck	Site 1	spring 2008	13/10/08	~80	20	140	52	440	580	74	3.04	509	281	7.13	3.64	14.1
Shrimptons Ck	Site 2	spring 2008	13/10/08	420	120	30	197	900	930	67	3.92	301	171	7.14	0	16.8
Porters Ck	Site 3	spring 2008	13/10/08	48	980	1870	26	1410	3280	91.5	4.88	456	251	7.4	7.3	16.3
Buffalo Ck	Site 4	spring 2008	13/10/08	~84	130	90	41	540	630	96.5	13.2	1008	573	7.16	0.3	17.1
Archers Ck	Site 5	spring 2008	13/10/08	220	50	380	33	370	750	85.5	2.74	501	279	7.25	3.4	16.5
Terrys Ck	Site 1	autumn 2008	3/5/08	150	10	270	24	310	580	72	3.21	474	284	8.0	8.40	21.9
Shrimptons Ck	Site 2	autumn 2008	3/5/08	200	10	10	53	670	680	74	3.17	358	214	7.4	5.80	17.3
Porters Ck	Site 3	autumn 2008	3/5/08	530	250	430	38	1100	1530	81	15.2	650	444	7.6	6.70	19.3
Buffalo Ck	Site 4	autumn 2008	3/5/08	620	40	450	35	370	820	91	37.2	885	552	8.1	6.80	21.0
Archers Ck	Site 5	autumn 2008	3/5/08	170	30	370	20	290	660	78	2.18	513	310	7.3	6.50	19.8
Terrys Ck	Site 1	autumn 2008	4/3/08	250	10	120	25	200	320	64	3.1	351	160	7.3	8.30	15.7
Shrimptons Ck	Site 2	autumn 2008	4/3/08	700	10	10	92	620	620	73	6.17	291	130	7.2	3.80	16.8
Porters Ck	Site 3	autumn 2008	4/3/08	370	750	300	27	1100	4100	100	3.96	505	290	7.6	9.30	16.9
Buffalo Ck	Site 4	autumn 2008	4/3/08	120	50	220	33	260	480	77	4.69	654	389	7.3	8.00	15.8
Archers Ck	Site 5	autumn 2008	4/3/08	160	40	110	22	230	340	83	1.48	470	253	7.3	7.10	16.7

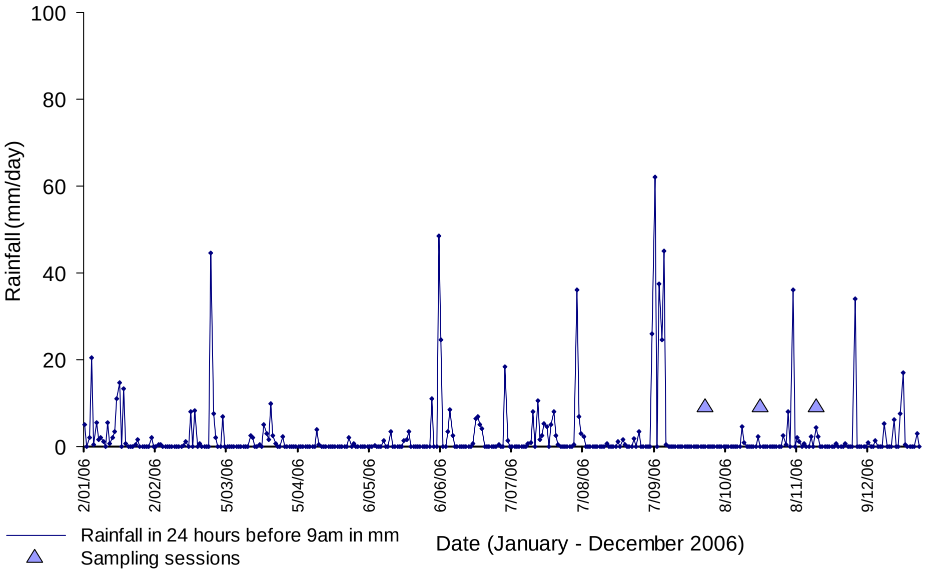
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature °C
Terrys Ck	Site 1	spring 2007	27/09/07	87	20	190	21	290	480	67	2	503	276	7.3	6.00	14.0
Shrimptons Ck	Site 2	spring 2007	26/09/07	300	160	30	54	650	680	72	2.6	403	232	7.1	2.35	16.9
Porters Ck	Site 3	spring 2007	27/09/07	1000	2600	3200	60	3110	6310	122	6.7	671	372	7.8	6.50	15.0
Buffalo Ck	Site 4	spring 2007	27/09/07	54	40	170	37	440	610	90	7.3	960	484	7.3	5.70	19.0
Archers Ck	Site 5	spring 2007	26/09/07	270	20	480	26	680	1160	59	3.2	527	304	7.5	6.30	15.1
Terrys Ck	Site 1	spring 2007	23/10/07	6	40	80	35	730	810	88	1.6	712	437	7.0	4.00	15.6
Shrimptons Ck	Site 2	spring 2007	22/10/07	150	<10	<10	111	1000	1000	77	11.9	519	350	6.7	2.90	19.8
Porters Ck	Site 3	spring 2007	23/10/07	160	1020	2600	68	1580	4180	90	8.2	505	326	7.7	7.30	19.3
Buffalo Ck	Site 4	spring 2007	23/10/07	140	110	60	73	790	850	108	7.7	1001	621	7.2	6.95	20.4
Archers Ck	Site 5	spring 2007	22/10/07	90	150	50	57	480	530	74	7.1	378	220	6.7	3.90	17.3
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	18.1
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	20.6
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	19.3
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	19.5
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	20.8
Terrys Ck	Site 1	autumn 2007	17-18/04/07	900	110	200	53	530	730	57	2.7	438	.	7.1	5.30	17.2
Shrimptons Ck	Site 2	autumn 2007	17-18/04/07	550	30	160	45	490	650	81	8.4	397	.	6.9	3.75	17.6
Porters Ck	Site 3	autumn 2007	17-18/04/07	10000	710	1590	20	1200	2790	98	3.2	3130	.	7.8	7.70	18.0
Buffalo Ck	Site 4	autumn 2007	17-18/04/07	740	130	120	48	540	660	81	8.6	912	.	6.7	3.83	17.2
Archers Ck	Site 5	autumn 2007	17-18/04/07	210	30	50	58	520	570	70	4.2	322	.	7.2	4.10	18.7
Shrimptons Ck	Site 2	spring 2006	28/09/06	69	130	140	64	580	720	94	7.8	717	420	7.1	4.33	17.3
Archers Ck	Site 5	spring 2006	28/09/06	160	<10	<10	104	520	520	83	2.0	509	293	7.4	6.53	15.4
Shrimptons Ck	Site 2	spring 2006	18/10/06	560	10	20	136	1180	1200	66	6.3	481	311	6.5	2.21	17.2
Archers Ck	Site 5	spring 2006	18/10/06	340	<10	10	90	500	510	70	2.3	448	295	6.9	3.94	18.3
Shrimptons Ck	Site 2	spring 2006	10/11/06	880	70	1200	68	800	2000	58	96.7	384	265	7.4	4.16	17.5
Archers Ck	Site 5	spring 2006	10/11/06	1700	20	40	50	360	400	84	1.8	502	310	7.2	7.19	18.6
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	20.2
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	21.1
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	25.2
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	22.1
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	20.6
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	15.7
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	16.8
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	19.8
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	19.2
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	18.4
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	11.9
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	13.1
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	15.3
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	11.7
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	12.4

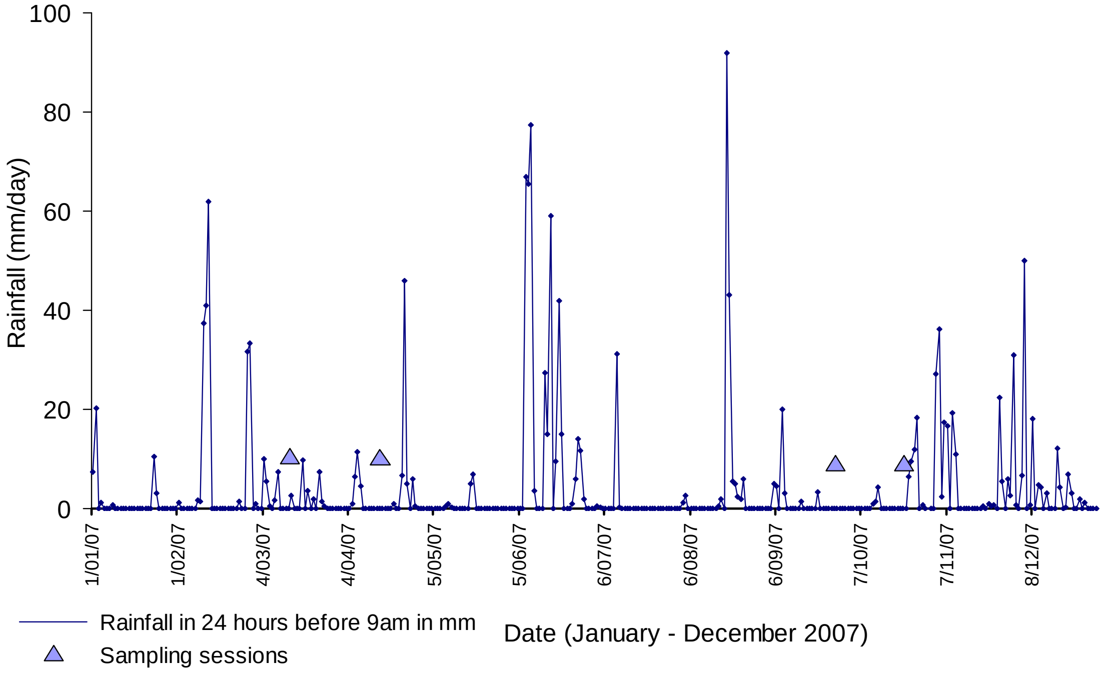
Stream	Site code	Season	Sample date	Faecal Coliforms CFU/100mL	Ammonia µg/L	Oxidised Nitrogen NOx µg/L	Total Phosphorus TP µg/L	Total Kjeldahl Nitrogen TKN µg/L	Total Nitrogen TN µg/L	Alkalinity mg CaCO3/L	Turbidity NTU	Conductivity µS/cm	Total Dissolved Solids mg/L	pH	Dissolved Oxygen DO mg/L	Temperature ^{O}C
Terrys Ck	Site 1	spring 2005	6-7/09/05	300	59	48	10	900	140	43	6.5	187	140	6.7	8.10	11.1
Shrimptons Ck	Site 2	spring 2005	6-7/09/05	90	5	37	40	280	65	42	7	164	140	6.7	4.31	12.9
Porters Ck	Site 3	spring 2005	6-7/09/05	500	110	58	20	2400	300	37	3	6141	4000	7.0	8.72	12.8
Buffalo Ck	Site 4	spring 2005	6-7/09/05	16	10	50	80	270	77	79	5.5	620	380	7.0	6.19	13.2
Archers Ck	Site 5	spring 2005	6-7/09/05	2000	17	26	110	560	82	56	10	245	160	6.8	5.56	14.7
Terrys Ck	Site 1	spring 2005	11-12/10/05	2000	10	33	10	520	85	47	2.2	245	180	7.1	4.49	13.6
Shrimptons Ck	Site 2	spring 2005	11-12/10/05	32000	16	36	100	540	90	43	3.9	246	150	7.2	3.26	15.7
Porters Ck	Site 3	spring 2005	11-12/10/05	16000	54	51	50	1300	180	31	4.5	3965	2600	7.6	8.67	17.9
Buffalo Ck	Site 4	spring 2005	11-12/10/05	6500	26	63	200	700	130	44	29	472	210	7.6	9.16	16.1
Archers Ck	Site 5	spring 2005	11-12/10/05	3800	6	54	100	500	100	30	5.1	206	100	7.3	4.56	20.6
Terrys Ck	Site 1	spring 2005	2/11/05	380	<1	2	40	370	39	37	1	159	110	6.5	5.40	20.8
Shrimptons Ck	Site 2	spring 2005	2/11/05	500	6	19	60	450	64	50	6.1	226	150	6.6	5.24	22.2
Porters Ck	Site 3	spring 2005	2/11/05	260	83	42	<10	2100	250	30	6.4	5633	3500	7.1	7.89	23.4
Buffalo Ck	Site 4	spring 2005	2/11/05	2000	5	28	50	350	63	60	4.1	299	200	7.0	5.65	21.0
Archers Ck	Site 5	spring 2005	2/11/05	640	6	18	40	560	74	79	12.6	350	210	6.9	5.58	25.1
Terrys Ck	Site 1	autumn 2005	30-31/03/05	60000	590	170	100	800	970	40	42	315	130	7.2	8.44	16.9
Shrimptons Ck	Site 2	autumn 2005	30-31/03/05	3400	20	240	40	280	520	52	9	305	170	6.7	4.46	17.1
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	18.3
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	17.8
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	19.6
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	15.8
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	17.3
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	18.3
Buffalo Ck	Site 4	autumn 2005	26-27/04/05	520	80	940	40	.	770	95	7.6	548	390	6.7	5.4	16.6
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	17.4
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	10.8
Shrimptons Ck	Site 2	autumn 2005	26-27/05/05	400	40	290	30	.	560	65	4.9	333	180	7.2	5.65	11.9
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	15.6
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	12.6
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	10.8
Terrys Ck	Site 1	spring 2004	14-15/09/04	80	.	.	110	.	.	50	2.4	.	150	6.8	5.08	10.6
Shrimptons Ck	Site 2	spring 2004	14-15/09/04	880	.	.	90	.	.	58	3.1	.	140	6.8	2.20	11.8
Archers Ck	Site 5	spring 2004	14-15/09/04	650	.	.	150	.	.	70	0.6	.	110	7.0	6.53	13.3
Terrys Ck	Site 1	spring 2004	11-12/10/04	44	.	.	30	.	.	64	0.3	.	310	7.6	5.01	16.1
Shrimptons Ck	Site 2	spring 2004	11-12/10/04	110	.	.	60	.	.	76	0.5	.	260	7.4	5.69	18.5
Archers Ck	Site 5	spring 2004	11-12/10/04	1500	.	.	50	.	.	82	0.8	.	230	7.5	4.27	18.6
Terrys Ck	Site 1	spring 2004	23-24/11/04	150	.	.	40	.	.	56	2.6	.	180	6.7	6.90	15.5
Shrimptons Ck	Site 2	spring 2004	23-24/11/04	1000	.	.	90	.	.	75	11.5	.	190	6.4	2.93	17.0
Archers Ck	Site 5	spring 2004	23-24/11/04	1700	.	.	40	.	.	84	4.7	.	270	6.6	8.02	17.2

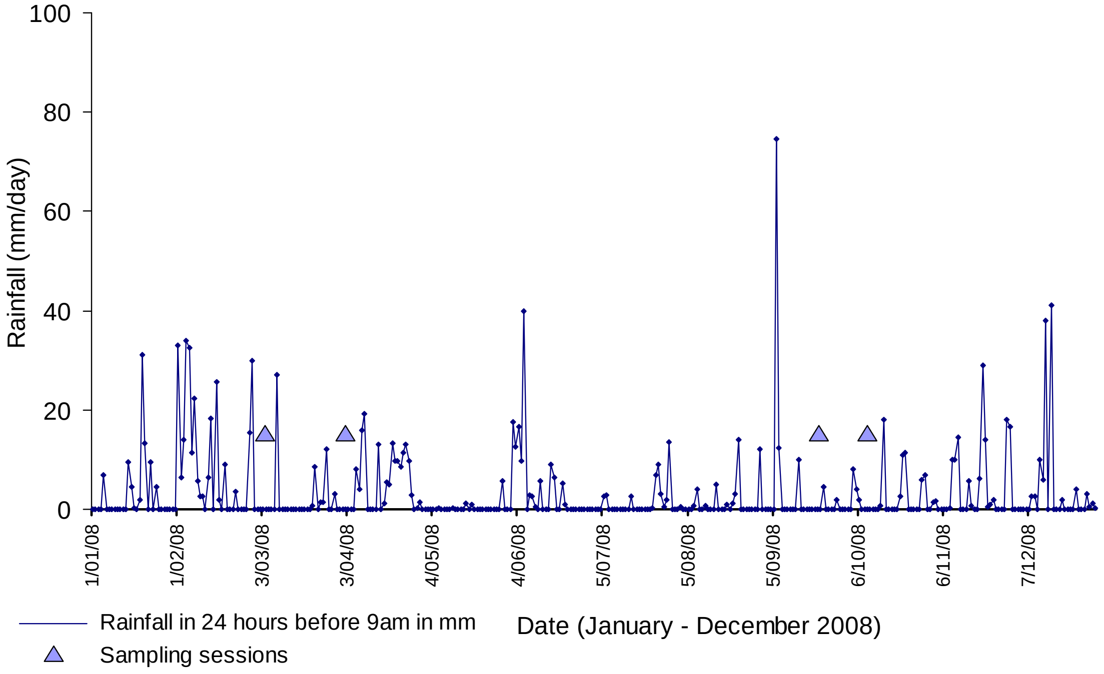
Appendix 3 Rainfall 2004 – 2008








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
7/11/07
8/12/07
Rainfall in 24 hours before 9am in mm
Sampling sessions
Date (January - December 2007)


100
80
60
40
20
0
Rainfall (mm/day)
1/01/08
1/02/08
3/03/08
3/04/08
4/05/08
4/06/08
5/07/08
5/08/08
5/09/08
6/10/08
6/11/08
7/12/08
Rainfall in 24 hours before 9am in mm
Sampling sessions
Date (January - December 2008)

Appendix 4 Macroinvertebrate results

			S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 spring 2004 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 autumn 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 2005 Archers Ck	S5 spring 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 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Autumn 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Spring 2008 Archers Ck	S5 Autumn 2009 Archers Ck	S5 Autumn 2009 Archers Ck	S5 Autumn 2009 Archers Ck	S5 Autumn 2009 Archers Ck	S5 Autumn 2009 Archers Ck	S5 Autumn 2009 Archers Ck
Aquatic mites	Acarina	Acarina	1	3	1	3	3				1				1	3	1		4			1											3	9		1						1								1			
Beetles	Coleoptera	Dytiscidae		3		1	1		2		1																								1					1													
Beetles	Coleoptera	Elmidae																														2																					
Beetles	Coleoptera	Hydraenidae													1						1																																
Beetles	Coleoptera	Hydrophilidae																				1																						1									
Beetles	Coleoptera	Psephenidae																																																			
Beetles	Coleoptera	Scirtidae																																		1																	
Caddisfly larvae	Trichoptera	Antipodoecidae																																																			
Caddisfly larvae	Trichoptera	Hydroptilidae	2		3																1									12	3	9				8	2	6		2		18	3	5	14	19	6	8	1	10	4	11	8
Caddisfly larvae	Trichoptera	Leptoceridae		1																																		1															
Dobsonfly larvae	Megaloptera	Corydalidae																																															1				
Dragonfly larvae	Odonata	Aeshnidae	1	1		2		14	5	5			11	8												3	2	3	1	1									1	2									2				
Dragonfly larvae	Odonata	Coenagrionidae	7	5	5	6	3	29	21	7	4	1	7	6		1					5			1			2	2	1	1									2	4	3				1	2		2	12	4	3	1	1
Dragonfly larvae	Odonata	Gomphidae																																																			
Dragonfly larvae	Odonata	Hemicorduliidae	2	6	1	4	3	18	25			1	7	5				1			2	10	1			3	4	23		9	1	1	2	9								1		1		1			2	2	1		
Dragonfly larvae	Odonata	Isostictidae																																																			
Dragonfly larvae	Odonata	Lestidae			3											1	1		2			3						3																		1							
Dragonfly larvae	Odonata	Libellulidae	2	4	5	3	9	8	1	15	14	7	2	4		1		1						6		2	2	3	4	2	1	2	2	1					4	3	1	1	1	1		1		1	17	9	9	26	6
Dragonfly larvae	Odonata	Megapodagrionidae		2		15	22	5	6		1	2	7	5	1			1			1	6		1	2	7			1		2				1				1	1		1	1	2	1				1	3		1	4
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	3	15	7		1	2	1	4	4	9	7	3	10	16	11	9	2	2	5		10	8	16	1	17	3		18	12	7	2			3	3		15	7	7	5	10	7	9	10	1	13	10	5
Freshwater Sponge	Porifera	Spongillidae																																																			
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											2	1	2	3	3	1		1	1						
Mayfly larvae	Ephemeroptera	Baetidae			1																			3		2								2					6	7	6							3	8		1		3
Moth Larvae	Lepidoptera	Pyralidae																													2										1							6	2	30			
Mussels	Bivalvia	Corbiculidae		1	1			1		3	3																																										
Mussels	Bivalvia	Sphaeriidae		3																	1									12		1	9	13	1							1											
Proboscis Worms	Nemertea	Nemertea																																	1																		
Round Worms	Nematoda	Nematoda		1	1																										2																						
Sand hoppers	Amphipoda	Ceinidae							2																											1																	
Sand hoppers	Amphipoda	Talitridae																																																			
Slatters	Isopoda	Oniscidae							7		1	3			1	4			1																			1															
Lacewing	Neuroptera	Sisyridae																																																	1		

			Archers Ck S5 spring 2004	Archers Ck S5 spring 2004	Archers Ck S5 spring 2004	Archers Ck S5 autumn 2005	Archers Ck S5 autumn 2005	Archers Ck S5 autumn 2005	Archers Ck S5 spring 2005	Archers Ck S5 spring 2005	Archers Ck S5 spring 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	Archers Ck S5 Autumn 2008	Archers Ck S5 Autumn 2008	Archers Ck S5 Autumn 2008	Archers Ck S5 Autumn 2008	Archers Ck S5 Autumn 2008	Archers Ck S5 Autumn 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Spring 2008	Archers Ck S5 Autumn 2009	Archers Ck S5 Autumn 2009	Archers Ck S5 Autumn 2009	Archers Ck S5 Autumn 2009	Archers Ck S5 Autumn 2009	Archers Ck S5 Autumn 2009
Snails	Gastropoda	Ancylidae																															1			1					2	2	5	1	3							
Snails	Gastropoda	Hydrobiidae	1	3	2										2	4	1	1	3		7	11	10	5	1					13	12	7	1	11	8	8	13	7	5	8	1	6	2	14	4	10	4	17	4	2		2	11
Snails	Gastropoda	Lymnaeidae							1				1									1		1												1										1			1			2	
Snails	Gastropoda	Physidae	3	5	10	4	4	1	9	5	13	1	5		8	4	12	15	3	7	8	7	11	7	2	9	13	6	1	18	10	11	15	12	21	11	5		9	7	1	8	11	16	1	12	4	7	9	1	1	5	5
Snails	Gastropoda	Planorbidae																																																			
Stonefly larvae	Plecoptera	Eustheniidae																																																			
True bugs	Hemiptera	Belostomatidae																																																			
True bugs	Hemiptera	Corixidae					1	10			1																							1	1													3	8	2			
True bugs	Hemiptera	Gelastocoridae													1				1																																		
True bugs	Hemiptera	Gerridae									1	1		1																																							
True bugs	Hemiptera	Hebridae																																																			
True bugs	Hemiptera	Mesoveliidae																																																			
True bugs	Hemiptera	Naucoridae																																																			
True bugs	Hemiptera	Nepidae																																																			
True bugs	Hemiptera	Notonectidae			2			11				2	1	4												2						1	7	12		2	1	9		2	11		2	2	13	1	9	13	3	13			3
True bugs	Hemiptera	Pleidae																																																			
True bugs	Hemiptera	Saldidae																															1																				
True bugs	Hemiptera	Veliidae	3	1		6	5	3			3	2	2	1	1		1		2	2	1		2		7	15	3	11			1					3	2	8	1	3	1	2		1	1				4				
True Fly larvae	Diptera	Bibionidae																			2																																
True Fly larvae	Diptera	Cecidomyiidae																																																			
True Fly larvae	Diptera	Ceratopogonidae																																		4		3	2	3			1					2	1	2		1	1
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						1															
True Fly larvae	Diptera	Psychodidae																			1										1							1															
True Fly larvae	Diptera	s-f Chironominae	9	10	11	9	5	22	69	94	38	71	72	109	22	15	19	27	6	8	34	32	18	13	34	25	35	25	23	33	18	40	33	42	24	8	16	9	10	9	17	16	12	18	16	19	15	12	20	17	26	17	8
True Fly larvae	Diptera	s-f Orthocladiinae	1		10	1									7	1		1	2	1	6				3	1	1			3	9	5			1	20	23	22	10	32	14	2		5	16	16	11	14	1	3	4	5	5
True Fly larvae	Diptera	s-f Tanypodinae	1	6	3	1	1	1	7				3	10	2	1		1	1	1	2	2	2	1	1	2	3	1	1	10	5	1	1	2	5				2			4	1	1		6	1	9		2			2
True Fly larvae	Diptera	Simuliidae													1										1						2	1					1		3							2		4	2	4	1	4	1
True Fly larvae	Diptera	Stratiomyidae	3	1		1	2	6	1			1		1		1	4		2	6			1	1				3				5		2	1	1	1	1	1			1		2		4		1	1	1		2	
True Fly larvae	Diptera	Syrphidae																				1																															
True Fly larvae	Diptera	Tipulidae	1	1										1				2					2									2			2	1	2		1	1		2		2	1		1						
Worms	Oligochaeta	Oligochaeta	4	6	12	4	16	15	24	19	11	8	13	14	12	9	8	11	3	1	4	8	3	8	11		10	17	3	16	23	6	2	8	5	4	5	2	1	3	3	10	8	7	13	8	4	7	2	11	4	2	10
Yabbies	Decapoda	Parastacidae																																																			
Yabbie cleaner	Temnocephala	Temnocephalidae																																																			

			S2 spring 2004 Shrimptons C	S2 spring 2004 Shrimptons C	S2 spring 2004 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C
Aquatic mites	Acarina	Acarina	1		3	1			1		2	4	5	4		1		2	1	1	4	7	1	1	11	2	4	9	2		1		2	1		6		2		1	1	4		3	11	2				3			
Beetles	Coleoptera	Dytiscidae																				1																															
Beetles	Coleoptera	Elmidae																																																			
Beetles	Coleoptera	Hydraenidae																																																			
Beetles	Coleoptera	Hydrophilidae																																							1					1							
Beetles	Coleoptera	Psephenidae																																																			
Beetles	Coleoptera	Scirtidae																																																			
Caddisfly larvae	Trichoptera	Antipodoecidae																																																			
Caddisfly larvae	Trichoptera	Hydroptilidae	2	3																										2	5	3												2	1	1							
Caddisfly larvae	Trichoptera	Leptoceridae			1																																																
Dobsonfly larvae	Megaloptera	Corydalidae																																																			
Dragonfly larvae	Odonata	Aeshnidae																								2	4	1	2		1																		1				
Dragonfly larvae	Odonata	Coenagrionidae	3	6		1		2	3			3	1			1		3			1			3	4	1	7	6	1	7	1	13	2	4	2	1	1	1	1			7	1	1	13	3	3	3	4	5			1
Dragonfly larvae	Odonata	Gomphidae	1																																																		
Dragonfly larvae	Odonata	Hemicorduliidae	1	4	2		1					7	4	1		5	2	2	4		1	4			7	1	9	6	14	2		5	2	2	1	2		2	1			1			1						2		
Dragonfly larvae	Odonata	Isostictidae														1								1	3	3	1	5	7	4	1	8	6	4	1								1		1				1	2			
Dragonfly larvae	Odonata	Lestidae			1												1			8		2	3																														
Dragonfly larvae	Odonata	Libellulidae		3						2	4	1		1												1	1	2			2					1				4				1							3	1	1
Dragonfly larvae	Odonata	Megapodagrionidae		2																		1	1	3	2	8	7	4	4	6	13	8	8			3	2	2		3		1		1						1	6		
Dragonfly larvae	Odonata	Synthemistidae																																																			
Dragonfly larvae	Odonata	Telephlebiidae																								1																											
Fairy shrimps	Decapoda	Atyidae																																																			
Flatworms	Turbellaria	Dugesiidae	2	4	9	14	19	11	14	12	10	7	8	9	4	1		2		8	3	2	2	4	4	4	7	11	1	7	9	13	5	1	1	8	13	17	13	9	17	10	11	4	12	9	5	8	4	14	7	16	4
Freshwater Sponge	Porifera	Spongillidae																																																			
Lacewing	Neuroptera	Osmylidae																													1																						
Leeches	Arhynchobdellida	Erpobdellidae						9																																													
Leeches	Arhynchobdellida	Hirudinidae																																																			
Leeches	Rhynchobdellida	Glossiphoniidae				15	5	9	7	9	12	1	1										1	1												10	2	1			3		6	2	1		1						
Mayfly larvae	Ephemeroptera	Baetidae																		1			1		1																						4	5	4	3	3		
Moth Larvae	Lepidoptera	Pyralidae																																																			
Mussels	Bivalvia	Corbiculidae		4		9	3	10	6	4	12	9	6	3																																							
Mussels	Bivalvia	Sphaeriidae	2	3	10										1																	1		1		3					1		1	1	1	3							
Proboscis Worms	Nemertea	Nemertea																																															1				
Round Worms	Nematoda	Nematoda	1																																																		
Sand hoppers	Amphipoda	Ceinidae																																																			
Sand hoppers	Amphipoda	Talitridae																																																			
Slatters	Isopoda	Oniscidae							2																1							1											1	1									
Lacewing	Neuroptera	Sisyridae																																																	1	

			S2 spring 2004 Shrimptons C	S2 spring 2004 Shrimptons C	S2 spring 2004 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 autumn 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 spring 2005 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 autumn 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 spring 2006 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 autumn 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 spring 2007 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Autumn 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Spring 2008 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C	S2 Autumn 2009 Shrimptons C
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									1	4					1				
Snails	Gastropoda	Lymnaeidae							1			1				1						1						1			1	1	1		1			1				1	1	1				1		3	2	1	2
Snails	Gastropoda	Physidae	6	7	10	17	17	12	14	20	15	5	11	11	13	16	8	13	10	10	13	9	14		1	15	16	8	4	17	17	29	17	9	4	14	8	4	8	6	13	17	10	8	10	14	14		4	2		8	6
Snails	Gastropoda	Planorbidae	2	3	10	11	2	6	4	11	11	2			3	1	6	1	2											2				3			1						1										
Stonefly larvae	Plecoptera	Eustheniidae																																																			
True bugs	Hemiptera	Belostomatidae																																																			
True bugs	Hemiptera	Corixidae		3	2				2																1		1	1		1	4		5	2	1		1															1	
True bugs	Hemiptera	Gelastocoridae						1	1	2											1																														1		
True bugs	Hemiptera	Gerridae																							1	1			1							1													1	1			
True bugs	Hemiptera	Hebridae																																																			
True bugs	Hemiptera	Mesoveliidae																								1																											
True bugs	Hemiptera	Naucoridae																																																			
True bugs	Hemiptera	Nepidae																									1					1																					
True bugs	Hemiptera	Notonectidae															2	2	1	4	2	1	1	2	5	1		2		1			1	1	1	5		3				4			14	1		1	3	8	1	6	
True bugs	Hemiptera	Pleidae										1																																									
True bugs	Hemiptera	Saldidae																																																			
True bugs	Hemiptera	Veliidae																		1					1	11	4							2																			
True Fly larvae	Diptera	Bibionidae																																																			
True Fly larvae	Diptera	Cecidomyiidae																																																			
True Fly larvae	Diptera	Ceratopogonidae	1												1																								1														
True Fly larvae	Diptera	Culicidae														2					8													1																			
True Fly larvae	Diptera	Dixidae																																																			
True Fly larvae	Diptera	Dolichopodidae																																																			
True Fly larvae	Diptera	Ephydridae																																																			
True Fly larvae	Diptera	Muscidae																																4																			
True Fly larvae	Diptera	Psychodidae																																																			
True Fly larvae	Diptera	s-f Chironominae	12	11	10		1		5	10	15		2	3	21	25	21	20	32	18	18	26	12	8	4	5	17	2	26	30	27	50	7	12	11				1			5	2	6	5	6	12	4		1	2		4
True Fly larvae	Diptera	s-f Orthocladiinae					1									1							1												1		1				1							1					
True Fly larvae	Diptera	s-f Tanypodinae														1		1			2		1			1		1			1	1	2	5			1										1				2		
True Fly larvae	Diptera	Simuliidae																																																			
True Fly larvae	Diptera	Stratiomyidae		1		1		4	1							1	1			1			1										1												1								1
True Fly larvae	Diptera	Syrphidae																																																			
True Fly larvae	Diptera	Tipulidae																																																			
Worms	Oligochaeta	Oligochaeta	7	6	12	10	9	17	16	13	17	13	11	17	10	4	8	1	8	10	3	3		7	5	4	1		6	12	2	5	5	5	3	3	5	2	4		3	1	6	2	2	8	9	1			2		
Yabbies	Decapoda	Parastacidae										1			2								1			2	1	3				1					1											1	1				
Yabbie cleaner	Temnocephala	Temnocephalidae																								1																											

			S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 autumn 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 spring 2005 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2006 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 autumn 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 spring 2007 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Autumn 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Spring 2008 Porters Ck	S3 Autumn 2009 Porters Ck	S3 Autumn 2009 Porters Ck	S3 Autumn 2009 Porters Ck	S3 Autumn 2009 Porters Ck	S3 Autumn 2009 Porters Ck	S3 Autumn 2009 Porters Ck
Aquatic mites	Acarina	Acarina	1					1		1				1		1																				1				1
Beetles	Coleoptera	Dytiscidae				1	1	2							2	1								2	1	4															
Beetles	Coleoptera	Elmidae																																							
Beetles	Coleoptera	Hydraenidae																																							
Beetles	Coleoptera	Hydrophilidae													3											1															
Beetles	Coleoptera	Psephenidae							1																																
Beetles	Coleoptera	Scirtidae			1										1							1																			
Caddisfly larvae	Trichoptera	Antipodoecidae										1														1										2	1	2	2		
Caddisfly larvae	Trichoptera	Hydroptilidae										3	3	7	4	5	1			1			1										2	3			1	1	4		
Caddisfly larvae	Trichoptera	Leptoceridae	1		1				1	1			3	4		3	1																					1			
Dobsonfly larvae	Megaloptera	Corydalidae																																							
Dragonfly larvae	Odonata	Aeshnidae	2	2	2	1			3	5	7		2																							1					
Dragonfly larvae	Odonata	Coenagrionidae	3	10	13	9		2	15	7	12	8	12	2	10	5	7	1	3	1		1		1				2	2				1			2	2	1	1	9	
Dragonfly larvae	Odonata	Gomphidae				1																																			
Dragonfly larvae	Odonata	Hemicorduliidae	9	8	8	11			5	5	13	10	6	2	9	3	6		2								2		2					1							
Dragonfly larvae	Odonata	Isostictidae	21	19	13	9	5	7	18	7	7	8	6	2	13	13	8	1	8	3	3	2						2	2						2	7			2	3	1
Dragonfly larvae	Odonata	Lestidae																																							
Dragonfly larvae	Odonata	Libellulidae	1	3	4	2	5	9	5	1	3	5	9	4	6	5	1		1				1	1			1									2			1	1	
Dragonfly larvae	Odonata	Megapodagrionidae	6	14	8	4		2	10	7	26	8	7	2	5	11	5	4	13	10	1	4	8	2	5	3	12	2	10	2	2	1	3	1		5		2	3	3	6
Dragonfly larvae	Odonata	Synthemistidae																																							
Dragonfly larvae	Odonata	Telephlebiidae																																							
Fairy shrimps	Decapoda	Atyidae	5				2		5	5	14	10	8	3	1	10	1									1											1				
Flatworms	Turbellaria	Dugesiidae	5	3		2						3	2	2					2			1		5	2	1			5				1	3	3			1		1	
Freshwater Sponge	Porifera	Spongillidae																																							
Lacewing	Neuroptera	Osmylidae																																							
Leeches	Arhynchobdellida	Erpobdellidae				2	2	1						2																											
Leeches	Arhynchobdellida	Hirudinidae																										1													
Leeches	Rhynchobdellida	Glossiphoniidae	2	7	5	3	4	5	8	16	3	2	3		1		2											1	1												
Mayfly larvae	Ephemeroptera	Baetidae	1																																		1		1		
Moth Larvae	Lepidoptera	Pyralidae																																				1			
Mussels	Bivalvia	Corbiculidae		4	2																																				
Mussels	Bivalvia	Sphaeriidae														1													1			3	1								
Proboscis Worms	Nemertea	Nemertea											1																							3					
Round Worms	Nematoda	Nematoda																														2									
Sand hoppers	Amphipoda	Ceinidae				3	1																																		
Sand hoppers	Amphipoda	Talitridae									1																	1													
Slatters	Isopoda	Oniscidae				1																4													1						
Lacewing	Neuroptera	Sisyridae																																							1

			S3 autumn 2005 Porters C	S3 autumn 2005 Porters C	S3 autumn 2005 Porters C	S3 spring 2005 Porters C	S3 spring 2005 Porters C	S3 spring 2005 Porters C	S3 autumn 2006 Porters C	S3 autumn 2006 Porters C	S3 autumn 2006 Porters C	S3 autumn 2007 Porters C	S3 autumn 2007 Porters C	S3 autumn 2007 Porters C	S3 autumn 2007 Porters C	S3 autumn 2007 Porters C	S3 autumn 2007 Porters C	S3 spring 2007 Porters C	S3 spring 2007 Porters C	S3 spring 2007 Porters C	S3 spring 2007 Porters C	S3 spring 2007 Porters C	S3 spring 2007 Porters C	S3 Autumn 2008 Porters C	S3 Autumn 2008 Porters C	S3 Autumn 2008 Porters C	S3 Autumn 2008 Porters C	S3 Autumn 2008 Porters C	S3 Autumn 2008 Porters C	S3 Spring 2008 Porters C	S3 Spring 2008 Porters C	S3 Spring 2008 Porters C	S3 Spring 2008 Porters C	S3 Spring 2008 Porters C	S3 Spring 2008 Porters C	S3 Autumn 2009 Porters C	S3 Autumn 2009 Porters C	S3 Autumn 2009 Porters C	S3 Autumn 2009 Porters C	S3 Autumn 2009 Porters C	S3 Autumn 2009 Porters C
Snails	Gastropoda	Ancylidae	1										1			1				3	1		7		1			1						3	2		1				
Snails	Gastropoda	Hydrobiidae	30	22	13	23	13	34	23	10	18	15	33	15	26	18	30	9	18	21	4	28	11	10	8	8	12	7	14	2	1	10		15	15	12	5	12	11	19	11
Snails	Gastropoda	Lymnaeidae																1				1								1			1								
Snails	Gastropoda	Physidae	12	10	7	4	8	7	2	7	3	10	8	6	5	4	9	3	10	14	11	6	6	3	5	5			1	8	6	5	15	17	4					2	1
Snails	Gastropoda	Planorbidae	4	6	6		2	2		2	2				2				1		1	1	3		1	1	1			1		1	1	1	4				2	1	
Stonefly larvae	Plecoptera	Eustheniidae							1																																
True bugs	Hemiptera	Belostomatidae																																							
True bugs	Hemiptera	Corixidae				1	2	9																		1	1							1							
True bugs	Hemiptera	Gelastocoridae																																							
True bugs	Hemiptera	Gerridae								1						1																		1							
True bugs	Hemiptera	Hebridae																																							
True bugs	Hemiptera	Mesoveliidae																																							
True bugs	Hemiptera	Naucoridae																																							
True bugs	Hemiptera	Nepidae				1																																			
True bugs	Hemiptera	Notonectidae	2		2	1			4	8		7	8	4	4	9	11				1	2		4	7	10	2	1	1	1		2	4	3	2		2	9	2	2	
True bugs	Hemiptera	Pleidae																																							
True bugs	Hemiptera	Saldidae																																							
True bugs	Hemiptera	Veliidae		3							2																				1										
True Fly larvae	Diptera	Bibionidae																																							
True Fly larvae	Diptera	Cecidomyiidae																										1													
True Fly larvae	Diptera	Ceratopogonidae																																							
True Fly larvae	Diptera	Culicidae				1						1			2											1		1													
True Fly larvae	Diptera	Dixidae																																							
True Fly larvae	Diptera	Dolichopodidae																																							
True Fly larvae	Diptera	Ephydridae																																							
True Fly larvae	Diptera	Muscidae																																							
True Fly larvae	Diptera	Psychodidae												1										1			1														
True Fly larvae	Diptera	s-f Chironominae	34	48	46	77	132	100		10	7	3	14	6	4	17	7	22	22	18	27	20	25	10	13	14	15	16	18	17	10	15		18		6	19	14	12	8	6
True Fly larvae	Diptera	s-f Orthocladiinae	7	1					1			6	7	5	1	4								6	19	13	1	2	1		1	2	3			12	4	7	3	1	5
True Fly larvae	Diptera	s-f Tanypodinae	4	2	14					18	11	3	4	5		4		1			1		2			1			1				15		12	2	1				1
True Fly larvae	Diptera	Simuliidae																						1																	
True Fly larvae	Diptera	Stratiomyidae		2		1							1		1	1	1	1	3				1	1	4	3		5	3			3		1					2		1
True Fly larvae	Diptera	Syrphidae																																							
True Fly larvae	Diptera	Tipulidae																1	1			1		1		1										1					
Worms	Oligochaeta	Oligochaeta	3	6	10	10	5	7	6	6	8		3	7	7			8	17	15	2	3	5	2	4	7			4	4	7	4	6	11	1	1	1		1	4	2
Yabbies	Decapoda	Parastacidae																																							
Yabbie cleaner	Temnocephala	Temnocephalidae																																							

			S4 autumn 2005Buffalo C	S4 autumn 2005Buffalo C	S4 autumn 2005Buffalo C	S4 spring 2005 Buffalo C	S4 spring 2005 Buffalo C	S4 spring 2005 Buffalo C	S4 autumn 2006Buffalo C	S4 autumn 2006Buffalo C	S4 autumn 2006Buffalo C	S4 autumn 2007Buffalo C	S4 autumn 2007Buffalo C	S4 autumn 2007Buffalo C	S4 autumn 2007Buffalo C	S4 autumn 2007Buffalo C	S4 autumn 2007Buffalo C	S4 spring 2007 Buffalo C	S4 spring 2007 Buffalo C	S4 spring 2007 Buffalo C	S4 spring 2007 Buffalo C	S4 spring 2007 Buffalo C	S4 spring 2007 Buffalo C	S4 Autumn 2008Buffalo C	S4 Autumn 2008Buffalo C	S4 Autumn 2008Buffalo C	S4 Autumn 2008Buffalo C	S4 Autumn 2008Buffalo C	S4 Autumn 2008Buffalo C	S4 Spring 2008 Buffalo C	S4 Spring 2008 Buffalo C	S4 Spring 2008 Buffalo C	S4 Spring 2008 Buffalo C	S4 Spring 2008 Buffalo C	S4 Spring 2008 Buffalo C	S4 Autumn 2009Buffalo C	S4 Autumn 2009Buffalo C	S4 Autumn 2009Buffalo C	S4 Autumn 2009Buffalo C	S4 Autumn 2009Buffalo C	S4 Autumn 2009Buffalo C
Aquatic mites	Acarina	Acarina	2	2	1	6	1	1											1					1																
Beetles	Coleoptera	Dytiscidae					2																																	
Beetles	Coleoptera	Elmidae																																						
Beetles	Coleoptera	Hydraenidae																														1								
Beetles	Coleoptera	Hydrophilidae	1		1					1										1					1															
Beetles	Coleoptera	Psephenidae																																						
Beetles	Coleoptera	Scirtidae		1																																				
Caddisfly larvae	Trichoptera	Antipodoecidae																																						
Caddisfly larvae	Trichoptera	Hydroptilidae			3							8	3	6	2	3	2		2	2		1			2	7	12	9	11			3					2	3	7	1	5
Caddisfly larvae	Trichoptera	Leptoceridae										1																													
Dobsonfly larvae	Megaloptera	Corydalidae																																						
Dragonfly larvae	Odonata	Aeshnidae	3	1	1			1	3	6	3		2	6	5	4	3							2	3	1	2														
Dragonfly larvae	Odonata	Coenagrionidae	5	8	15				5	6	12	1		4	9	2	4	2	2	5	1				3			1	2							1	4	3	2	1	7
Dragonfly larvae	Odonata	Gomphidae																																						
Dragonfly larvae	Odonata	Hemicorduliidae	1	16	19	7			13	4	2	1	5	10	6	8	10			2	1	1	4	1	1	1			1												4
Dragonfly larvae	Odonata	Isostictidae		1	2	1			2		2	1	1	2	3	6	5	3		8	5		5		2	1		2				1				1		2	1	1	1
Dragonfly larvae	Odonata	Lestidae																																						
Dragonfly larvae	Odonata	Libellulidae		5	2	2	1	13	13	10	4	2		7	3	7		2							2		1		1									1			
Dragonfly larvae	Odonata	Megapodagrionidae	9	21	19	20		3	9	2	8	2	3	5	5	9	3	1	1	9	10	2	5	8	9	7	9	3	3	1	1	2	3	4		2	4	2	5	5	10
Dragonfly larvae	Odonata	Synthemistidae		1																																				
Dragonfly larvae	Odonata	Telephlebiidae											1																											
Fairy shrimps	Decapoda	Atyidae																																						
Flatworms	Turbellaria	Dugesiidae	4	6	5	3	2	6	3	4	3			3	8	4	4				2	4		5	5	4	6	2	5			2	3				2	6	3	2	9
Freshwater Sponge	Porifera	Spongillidae																																						
Lacewing	Neuroptera	Osmylidae																																						
Leeches	Arhynchobdellida	Erpobdellidae			1																																			
Leeches	Arhynchobdellida	Hirudinidae																																						
Leeches	Rhynchobdellida	Glossiphoniidae	2	1	2				4	9		1			2																									
Mayfly larvae	Ephemeroptera	Baetidae								4		14	8	13												1										1		1			1
Moth Larvae	Lepidoptera	Pyralidae																																						
Mussels	Bivalvia	Corbiculidae	3	8	7	5	1	11	4	6	7																														1
Mussels	Bivalvia	Sphaeriidae										1		1		3	9				1		2						1				9	1							
Proboscis Worms	Nemertea	Nemertea																																				2		2	3
Round Worms	Nematoda	Nematoda													1																									
Sand hoppers	Amphipoda	Ceinidae		1	2	2	8																																	
Sand hoppers	Amphipoda	Talitridae								1																														
Slatters	Isopoda	Oniscidae				3	4	2	1																1								1								
Lacewing	Neuroptera	Sisyridae																																							1

			S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 autumn 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 spring 2005 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2006 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 autumn 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 spring 2007 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Autumn 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Spring 2008 Buffalo Ck	S4 Autumn 2009 Buffalo Ck	S4 Autumn 2009 Buffalo Ck	S4 Autumn 2009 Buffalo Ck	S4 Autumn 2009 Buffalo Ck	S4 Autumn 2009 Buffalo Ck	S4 Autumn 2009 Buffalo Ck
Snails	Gastropoda	Ancylidae																					1									1									
Snails	Gastropoda	Hydrobiidae	6	4	18	11	13	7	2			9	12	4	4	2	10	7	10	6	3	5	9		7	10	14	17	4	5	14	6	12	6	19	3	10	11	3	17	14
Snails	Gastropoda	Lymnaeidae							1		1	1	1	4	3	6	2			4	2				1	3	1					1	2				1	1	1	1	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	7	18	26	2	2	15	5	12	25	16	16	14	7	4	9	12	13	11
Snails	Gastropoda	Planorbidae	2	2	3			1				3			4	8	2	1	1	6		2		5	9	3			1	1			5	1	1	3			6	7	6
Stonefly larvae	Plecoptera	Eustheniidae																																							
True bugs	Hemiptera	Belostomatidae																																							
True bugs	Hemiptera	Corixidae	1				1								1																										
True bugs	Hemiptera	Gelastocoridae												1							1	1			1																
True bugs	Hemiptera	Gerridae							1	1		1			1		1							1		3										1	1				1
True bugs	Hemiptera	Hebridae																							1																
True bugs	Hemiptera	Mesoveliidae								1				1																											
True bugs	Hemiptera	Naucoridae																																							
True bugs	Hemiptera	Nepidae																																							
True bugs	Hemiptera	Notonectidae	11	10	10	4	4	1	14	10	14	10	10	11	7	13	12	4	1	2	1	3	2	13	5	14	9	12	7	1	1	1				6	13	3	7	2	5
True bugs	Hemiptera	Pleidae																					1																		
True bugs	Hemiptera	Saldidae																																							
True bugs	Hemiptera	Veliidae												1					1			1			2	2	1						1								
True Fly larvae	Diptera	Bibionidae																																							
True Fly larvae	Diptera	Cecidomyiidae																																							
True Fly larvae	Diptera	Ceratopogonidae			1						2	1								1																1					
True Fly larvae	Diptera	Culicidae		1			5			1	2								2																		1				
True Fly larvae	Diptera	Dixidae																																							
True Fly larvae	Diptera	Dolichopodidae																																							
True Fly larvae	Diptera	Ephydridae																																							
True Fly larvae	Diptera	Muscidae																																							
True Fly larvae	Diptera	Psychodidae																																							
True Fly larvae	Diptera	s-f Chironominae	9	13	36	26	31	74	78	46	56	14	29	16	20	10	23	51	28	19	9	19	13	8	10	18	17	7	23	6	5	25	18	11	25	7	12	3	13	12	5
True Fly larvae	Diptera	s-f Orthocladiinae	2						2	4	2	2			1										4	5	15	4	18							2	2	2	5	3	1
True Fly larvae	Diptera	s-f Tanypodinae	2	2	7	2					4	1	6	3	5	2	2		1	4		2	2				3	3									5	2			1
True Fly larvae	Diptera	Simuliidae					1																																		
True Fly larvae	Diptera	Stratiomyidae	2	1	3	1			1	1	5	3		1	2	1	1			1						1	1	2									1			2	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		3		4	1	1	1	1	1	10		2	1					
Yabbies	Decapoda	Parastacidae																																							
Yabbie cleaner	Temnocephala	Temnocephalidae																																							

			spring 2004 Terrys Ck S1	spring 2004 Terrys Ck S1	spring 2004 Terrys Ck S1	autumn 2005 Terrys Ck S1	autumn 2005 Terrys Ck S1	autumn 2005 Terrys Ck S1	spring 2005 Terrys Ck S1	spring 2005 Terrys Ck S1	spring 2005 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2006 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	autumn 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	spring 2007 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Autumn 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Spring 2008 Terrys Ck S1	Autumn 2009 Terrys Ck S1	Autumn 2009 Terrys Ck S1	Autumn 2009 Terrys Ck S1	Autumn 2009 Terrys Ck S1	Autumn 2009 Terrys Ck S1	Autumn 2009 Terrys Ck S1
Aquatic mites	Acarina	Acarina				2		1	1	7	4	2	3	2	1	2		2		1			2		5													2		2	1	1		
Beetles	Coleoptera	Dytiscidae								1																					1													
Beetles	Coleoptera	Elmidae	1		3	6	1				3	4	1			4				2			1		1		2		1								1				1			2
Beetles	Coleoptera	Hydraenidae																1									1																	
Beetles	Coleoptera	Hydrophilidae																																	1									
Beetles	Coleoptera	Psephenidae																																										
Beetles	Coleoptera	Scirtidae	1					1										1		1																								
Caddisfly larvae	Trichoptera	Antipodoecidae																																										
Caddisfly larvae	Trichoptera	Hydroptilidae		1								1			1										4												1		1				2	
Caddisfly larvae	Trichoptera	Leptoceridae																																										
Dobsonfly larvae	Megaloptera	Corydalidae										1																																
Dragonfly larvae	Odonata	Aeshnidae				1					1	1				1			2																	1			1					
Dragonfly larvae	Odonata	Coenagrionidae	1	1	3		3	4			7	7	5	2	5	1		3		2	1	1	1						1										2	5	1	1		
Dragonfly larvae	Odonata	Gomphidae	1																																									
Dragonfly larvae	Odonata	Hemicorduliidae	2	4	7	2	6	20	21			17	16	26	3	2		5	5	6	3	1		1	10	5						2			1				1	3	2			1
Dragonfly larvae	Odonata	Isostictidae			2	6	8	6	8	5	7	4	2	4	3	2	1	10		1					2	5			6	1	1	5			2	2		3	6	4	2	2	4	1
Dragonfly larvae	Odonata	Lestidae							6																																			
Dragonfly larvae	Odonata	Libellulidae								14	13	2	1	4	1		2		2	4					1	1	1		1											1	1	1		
Dragonfly larvae	Odonata	Megapodagrionidae	6	10	12	16	26	14	11	8	7	42	17	18	18	11	6	8	16	16	16	9	3	8	8	12	12	7	10	8	13	6	8	11	6	19	10	5	17	9	13	11	12	13
Dragonfly larvae	Odonata	Synthemistidae																												1														
Dragonfly larvae	Odonata	Telephlebiidae																												1														
Fairy shrimps	Decapoda	Atyidae			1																																							
Flatworms	Turbellaria	Dugesiidae	1	3	3	6	14	4	2	2	3	10	2	11	3	2	10	9	8	12	10	14	1	8	2	6	5	2	3	2	3	2	2	1	4		2	5	6	4	2	4		3
Freshwater Sponge	Porifera	Spongillidae																																			1							
Lacewing	Neuroptera	Osmylidae																																										
Leeches	Arhynchobdellida	Erpobdellidae																																						1				
Leeches	Arhynchobdellida	Hirudinidae														1																												
Leeches	Rhynchobdellida	Glossiphoniidae				3	2	1		1	1	2	2		1	1			1											1		1	1											
Mayfly larvae	Ephemeroptera	Baetidae														1	1																						2			1		3
Moth Larvae	Lepidoptera	Pyralidae																			1																							
Mussels	Bivalvia	Corbiculidae		5	1	3	5	10	2	9	3	9		8																														
Mussels	Bivalvia	Sphaeriidae	4	1	3											4		2	4				4	1	3	4	4						3		1	1	2	12						
Proboscis Worms	Nemertea	Nemertea															1																						8		2			
Round Worms	Nematoda	Nematoda																																										
Sand hoppers	Amphipoda	Ceinidae				3		1	1	3																																		
Sand hoppers	Amphipoda	Talitridae											1	2		1				1					1					1	1		1					1						
Slatters	Isopoda	Oniscidae							1																												1							
Lacewing	Neuroptera	Sisyridae																																								1		

			spring 2004 Terrys Ck	spring 2004 Terrys Ck	spring 2004 Terrys Ck	autumn 2005 Terrys Ck	autumn 2005 Terrys Ck	autumn 2005 Terrys Ck	spring 2005 Terrys Ck	spring 2005 Terrys Ck	spring 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	Autumn 2008 Terrys Ck	Autumn 2008 Terrys Ck	Autumn 2008 Terrys Ck	Autumn 2008 Terrys Ck	Autumn 2008 Terrys Ck	Autumn 2008 Terrys Ck	Spring 2008 Terrys Ck	Spring 2008 Terrys Ck	Spring 2008 Terrys Ck	Spring 2008 Terrys Ck	Spring 2008 Terrys Ck	Spring 2008 Terrys Ck	Autumn 2009 Terrys Ck	Autumn 2009 Terrys Ck	Autumn 2009 Terrys Ck	Autumn 2009 Terrys Ck	Autumn 2009 Terrys Ck	Autumn 2009 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	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1	S1
Snails	Gastropoda	Ancylidae			1																				1								3	1		1								
Snails	Gastropoda	Hydrobiidae	4	7	6	11	10	13		14	11	25	4	14	26	8	10	18	34	12	15	21	17	7	6	13	9	11	8	13	17	17	22	14	13	9	10	12	13	11	7	22	13	14
Snails	Gastropoda	Lymnaeidae	1						5	3		1					1																		1						1			
Snails	Gastropoda	Physidae	4	4	6	3	8	8	12	11	7	1	9	9	6	1	4	13	10	11	8	6	2	12	7	7	7	4	8	2	9	5	14	4	14	10	10	11	7	1		9	6	3
Snails	Gastropoda	Planorbidae		1	5	2	4	4	1		4	2			1			1	1	5		1		1	3	2	1		1								1	2						
Stonefly larvae	Plecoptera	Eustheniidae																																										
True bugs	Hemiptera	Belostomatidae	1																																									
True bugs	Hemiptera	Corixidae									5																																	
True bugs	Hemiptera	Gelastocoridae						1							1							1															1	1	2	1				
True bugs	Hemiptera	Gerridae		1				2		1	2	3	3	3				4	2										1			1								1	1	2	1	
True bugs	Hemiptera	Hebridae																																										
True bugs	Hemiptera	Mesoveliidae																																										
True bugs	Hemiptera	Naucoridae			1		1																																					
True bugs	Hemiptera	Nepidae																1																										
True bugs	Hemiptera	Notonectidae			3	11	2	7	4	1	2	5	6	4	3	4	7	11	3	3							4	4	7	6	7	4			2				1	8	9	3	3	3
True bugs	Hemiptera	Pleidae																																										
True bugs	Hemiptera	Saldidae																																										
True bugs	Hemiptera	Veliidae						3			1	4	1			1	2				1			5							2	1			1	3			1		7			1
True Fly larvae	Diptera	Bibionidae																																										
True Fly larvae	Diptera	Cecidomyiidae																																										
True Fly larvae	Diptera	Ceratopogonidae						1		2																						1	1			6								
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	3	17	28	33	32	30	2	19	5	8	15	13	9	13	5	41	16	33	17	18	17	5		2	1	3	3	14	19	15		9	6	2		2		2	
True Fly larvae	Diptera	s-f Orthocladiinae	2		2	2		1					1		7	5	2			2	1				2		1		1								2		3	3				1
True Fly larvae	Diptera	s-f Tanypodinae		2	1	3	4	21	11	6	1	1	9	11	14	1	5	8	1	3	1	4	1		1	1	5		2	1			4		1	11	2		4	3	1		1	4
True Fly larvae	Diptera	Simuliidae							1		1					3		3			1		1																		1		2	1
True Fly larvae	Diptera	Stratiomyidae	1			1	2			1		5				1		3	1	1			1					1	2		1		1		1				2	1			1	
True Fly larvae	Diptera	Syrphidae																																										
True Fly larvae	Diptera	Tipulidae				4																		1	1				1															1
Worms	Oligochaeta	Oligochaeta	7	10	7	4	15	8	9	15	7	18	14	17	4	8	4	4	1	3	8	8	4	4		2	4	1	3	3	3		7	4	1	3	3	11	2	1	7	2	2	2
Yabbies	Decapoda	Parastacidae																																										
Yabbie cleaner	Temnocephala	Temnocephalidae																																										

Appendix 5 SIMPER output

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

```
Data worksheet
Name: All 5 creeks merged 2009 Sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

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

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

Group Archers Ck
Average similarity: 61.39

Species                               Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae         11.54     11.04      3.36      17.98    17.98
Worms Oligochaeta                         6.55      6.78      5.14      11.04    29.02
Snails Physidae                           5.89      5.07      3.12       8.25    37.28
Flatworms Dugesiidae                      5.42      4.47      2.28       7.29    44.56
Dragonfly larvae Libellulidae             3.89      3.17      2.24       5.16    49.72
Dragonfly larvae Hemicorduliidae          3.50      2.85      1.37       4.64    54.36
True Fly larvae s-f Tanypodinae           3.11      2.84      3.06       4.62    58.99
Dragonfly larvae Coenagrionidae           3.44      2.81      1.80       4.57    63.56
Dragonfly larvae Megapodagrionidae        3.06      2.64      2.72       4.30    67.86
True bugs Veliidae                        2.88      2.32      2.29       3.79    71.64
Snails Hydrobiidae                        3.86      2.13      0.76       3.46    75.10
True Fly larvae Stratiomyidae             2.32      2.05      3.38       3.34    78.44
True bugs Notonectidae                    3.08      1.97      1.01       3.21    81.65
True Fly larvae s-f Orthocladiinae        3.94      1.91      0.88       3.11    84.76
Dragonfly larvae Aeshnidae                2.07      1.35      0.86       2.20    86.95
Leeches Glossiphoniidae                   2.03      1.30      0.95       2.12    89.08
Caddisfly larvae Hydroptilidae            2.74      0.93      0.50       1.52    90.60

Group Buffalo Ck
Average similarity: 64.15

Species                               Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae         10.08     10.80      4.60      16.83    16.83
Snails Physidae                           7.20      7.24      2.51      11.29    28.12
Snails Hydrobiidae                        5.96      6.01      2.10       9.36    37.48
Dragonfly larvae Megapodagrionidae        5.19      5.47      7.51       8.53    46.01
True bugs Notonectidae                    5.22      4.54      2.63       7.07    53.08
Worms Oligochaeta                         4.32      3.87      2.13       6.03    59.11
Flatworms Dugesiidae                      3.66      3.63      5.47       5.65    64.77
Dragonfly larvae Hemicorduliidae          3.27      2.28      1.42       3.55    68.32
Snails Planorbidae                        2.84      2.27      1.33       3.54    71.86
Dragonfly larvae Coenagrionidae           3.05      2.06      0.99       3.22    75.07
Dragonfly larvae Isostictidae             2.41      1.93      2.64       3.00    78.07
True Fly larvae s-f Tanypodinae           2.42      1.88      1.52       2.93    81.01
Dragonfly larvae Libellulidae             2.58      1.68      1.20       2.62    83.63
Caddisfly larvae Hydroptilidae            2.66      1.50      0.93       2.33    85.97
True Fly larvae Stratiomyidae             1.74      1.32      1.40       2.05    88.02
Snails Lymnaeidae                         1.80      1.21      1.01       1.89    89.91
True Fly larvae s-f Orthocladiinae        2.08      0.81      0.64       1.26    91.17
```

Group Porters Ck

```
Average similarity: 63.54

Species                                 Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Hydrobiidae                          8.43      9.44      8.35      14.86    14.86
True Fly larvae s-f Chironominae            9.60      9.23      2.98      14.52    29.38
Dragonfly larvae Megapodagrionidae          5.00      5.06      3.10       7.97    37.35
Worms Oligochaeta                           4.70      5.05      4.72       7.95    45.30
Snails Physidae                             4.96      4.66      2.46       7.34    52.64
Dragonfly larvae Isostictidae               4.47      3.87      2.25       6.09    58.73
Dragonfly larvae Coenagrionidae             3.80      3.21      2.19       5.05    63.78
True bugs Notonectidae                      3.39      2.87      2.01       4.52    68.31
True Fly larvae s-f Tanypodinae             3.06      2.32      1.23       3.66    71.96
Snails Planorbidae                          2.27      2.31      3.84       3.63    75.59
Dragonfly larvae Hemicorduliidae            2.94      1.92      1.16       3.03    78.62
Dragonfly larvae Libellulidae               2.52      1.81      1.43       2.84    81.46
Flatworms Dugesiidae                        2.04      1.70      1.50       2.68    84.14
True Fly larvae s-f Orthocladiinae          2.90      1.67      0.81       2.63    86.77
True Fly larvae Stratiomyidae               1.80      1.44      1.46       2.27    89.04
Leeches Glossiphoniidae                     2.26      1.35      0.90       2.12    91.16
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Group Shrimptons Ck

```
Average similarity: 58.22

Species                                 Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Physidae                             7.32     10.06      5.16      17.27    17.27
Flatworms Dugesiidae                        6.33      9.29      4.07      15.95    33.22
Worms Oligochaeta                           5.29      7.23      2.41      12.43    45.65
True Fly larvae s-f Chironominae            5.83      4.68      1.48       8.04    53.69
Dragonfly larvae Coenagrionidae             3.19      3.67      3.14       6.31    60.00
Aquatic mites Acarina                       3.02      3.45      2.13       5.93    65.93
Leeches Glossiphoniidae                     2.85      2.98      1.00       5.11    71.04
Dragonfly larvae Hemicorduliidae            2.59      2.31      1.34       3.98    75.02
True bugs Notonectidae                      2.26      1.74      0.77       2.98    78.00
Snails Planorbidae                          2.08      1.62      0.84       2.78    80.79
Dragonfly larvae Libellulidae               1.42      1.47      1.02       2.52    83.30
Snails Lymnaeidae                           1.35      1.39      1.66       2.39    85.69
Dragonfly larvae Megapodagrionidae          2.20      1.29      0.71       2.22    87.91
Mussels Corbiculidae                        1.51      0.79      0.30       1.35    89.27
True Fly larvae s-f Tanypodinae             1.12      0.72      0.81       1.24    90.51
```

Group Terrys Ck

```
Average similarity: 71.71

Species                                 Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae          8.16      8.53      8.77      11.89    11.89
Snails Hydrobiidae                          8.24      8.15      4.35      11.37    23.26
Snails Physidae                             5.98      5.70      5.16       7.95    31.20
True Fly larvae s-f Chironominae            7.25      5.52      2.40       7.70    38.90
Worms Oligochaeta                           5.37      5.00      6.59       6.97    45.87
Flatworms Dugesiidae                        5.07      4.83      7.95       6.74    52.61
True Fly larvae s-f Tanypodinae             4.48      3.93      5.05       5.49    58.10
Dragonfly larvae Isostictidae               3.92      3.51      5.17       4.90    63.00
True bugs Notonectidae                      3.92      2.97      1.31       4.14    67.13
Dragonfly larvae Hemicorduliidae            4.26      2.92      1.75       4.07    71.20
True bugs Veliidae                          2.11      2.05      5.94       2.86    74.06
Beetles Elmidae                             2.05      1.75      3.84       2.44    76.50
True Fly larvae Stratiomyidae               1.85      1.73      3.76       2.42    78.92
Dragonfly larvae Coenagrionidae             2.40      1.66      1.37       2.31    81.23
True Fly larvae s-f Orthocladiinae          1.96      1.59      4.07       2.22    83.45
Aquatic mites Acarina                       2.10      1.51      1.59       2.11    85.56
Snails Planorbidae                          2.13      1.49      1.51       2.07    87.63
Leeches Glossiphoniidae                     1.73      1.28      1.49       1.78    89.41
Mussels Sphaeriidae                         2.02      1.14      0.71       1.58    91.00
```

```
Groups Archers Ck  &  Buffalo Ck
Average dissimilarity = 42.30

                                   Group Archers Ck  Group Buffalo Ck
Species                            Av.Abund    Av.Abund    Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Orthocladiinae     3.94        2.08       2.04      1.17         4.82     4.82
Snails Hydrobiidae                     3.86        5.96       2.00      1.10         4.73     9.55
True Fly larvae s-f Chironominae      11.54       10.08       1.98      1.41         4.68    14.22
Caddisfly larvae Hydroptilidae         2.74        2.66       1.75      1.35         4.15    18.37
True bugs Notonectidae                 3.08        5.22       1.75      1.48         4.13    22.50
Snails Physidae                        5.89        7.20       1.68      1.32         3.97    26.46
Snails Planorbidae                     0.00        2.84       1.67      1.87         3.94    30.40
Worms Oligochaeta                      6.55        4.32       1.59      1.64         3.76    34.16
Flatworms Dugesiidae                   5.42        3.66       1.51      1.63         3.58    37.74
Dragonfly larvae Megapodagrionidae     3.06        5.19       1.40      2.00         3.32    41.06
Dragonfly larvae Isostictidae          0.00        2.41       1.39      1.99         3.28    44.34
Dragonfly larvae Libellulidae          3.89        2.58       1.37      1.21         3.24    47.58
True bugs Veliidae                     2.88        0.71       1.36      1.39         3.21    50.79
Dragonfly larvae Hemicorduliidae       3.50        3.27       1.33      1.39         3.16    53.95
Dragonfly larvae Coenagrionidae        3.44        3.05       1.32      1.27         3.12    57.06
Dragonfly larvae Aeshnidae             2.07        1.75       1.12      1.26         2.64    59.70
Mayfly larvae Baetidae                 1.57        1.11       1.11      0.93         2.63    62.33
Mussels Sphaeriidae                    0.89        1.54       1.06      1.13         2.50    64.83
True Fly larvae Culicidae              1.82        0.92       1.04      1.15         2.45    67.27
Leeches Glossiphoniidae                2.03        1.16       1.03      1.31         2.43    69.70
Mussels Corbiculidae                   0.38        1.56       0.99      0.91         2.34    72.04
Fairy shrimps Atyidae                  1.51        0.00       0.94      0.73         2.23    74.27
True Fly larvae s-f Tanypodinae        3.11        2.42       0.84      1.19         1.97    76.25
Snails Lymnaeidae                      0.86        1.80       0.79      1.64         1.87    78.12
Aquatic mites Acarina                  1.45        0.88       0.77      1.22         1.82    79.94
True Fly larvae Simuliidae             1.24        0.13       0.67      1.04         1.59    81.53
True Fly larvae Stratiomyidae          2.32        1.74       0.65      1.15         1.53    83.06
Slatters Oniscidae                     1.00        0.88       0.65      1.15         1.53    84.59
True bugs Corixidae                    1.04        0.38       0.63      0.87         1.50    86.09
True Fly larvae Tipulidae              1.08        0.13       0.61      1.08         1.45    87.53
True Fly larvae Ceratopogonidae        0.79        0.68       0.60      1.08         1.41    88.94
True bugs Gerridae                     0.27        0.86       0.49      1.09         1.16    90.10

Groups Archers Ck  &  Porters Ck
Average dissimilarity = 44.11

                                   Group Archers Ck        Group Porters Ck
Species                            Av.Abund       Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
Snails Hydrobiidae                     3.86           8.43     2.85      1.31         6.46     6.46
True Fly larvae s-f Chironominae      11.54           9.60     2.65      1.45         6.00    12.46
Dragonfly larvae Isostictidae          0.00           4.47     2.62      2.44         5.93    18.39
Flatworms Dugesiidae                   5.42           2.04     2.08      1.63         4.72    23.12
True Fly larvae s-f Orthocladiinae     3.94           2.90     2.03      1.23         4.59    27.71
Caddisfly larvae Hydroptilidae         2.74           1.36     1.63      1.17         3.69    31.40
Snails Physidae                        5.89           4.96     1.48      1.41         3.36    34.75
True bugs Veliidae                     2.88           0.52     1.46      1.48         3.30    38.06
Dragonfly larvae Megapodagrionidae     3.06           5.00     1.40      1.66         3.18    41.24
Snails Planorbidae                     0.00           2.27     1.37      2.85         3.11    44.35
Dragonfly larvae Hemicorduliidae       3.50           2.94     1.35      1.36         3.07    47.41
Dragonfly larvae Libellulidae          3.89           2.52     1.34      1.21         3.03    50.44
True bugs Notonectidae                 3.08           3.39     1.32      1.54         2.99    53.43
Fairy shrimps Atyidae                  1.51           2.04     1.31      1.19         2.97    56.40
Worms Oligochaeta                      6.55           4.70     1.24      1.69         2.81    59.21
Dragonfly larvae Coenagrionidae        3.44           3.80     1.20      1.38         2.72    61.93
Leeches Glossiphoniidae                2.03           2.26     1.10      1.32         2.50    64.43
Dragonfly larvae Aeshnidae             2.07           1.22     1.10      1.23         2.49    66.92
True Fly larvae s-f Tanypodinae        3.11           3.06     1.09      1.59         2.46    69.38
True Fly larvae Culicidae              1.82           0.52     1.06      1.01         2.41    71.79
Mayfly larvae Baetidae                 1.57           0.25     0.92      0.81         2.08    73.88
Snails Ancylidae                       0.62           1.30     0.79      1.17         1.80    75.67
True bugs Corixidae                    1.04           0.73     0.76      0.94         1.72    77.39
Mussels Sphaeriidae                    0.89           0.72     0.71      0.81         1.61    79.00
True Fly larvae Stratiomyidae          2.32           1.80     0.68      1.31         1.55    80.55
True Fly larvae Simuliidae             1.24           0.13     0.68      1.04         1.54    82.09
Aquatic mites Acarina                  1.45           0.73     0.67      1.14         1.53    83.61
True Fly larvae Tipulidae              1.08           0.52     0.62      1.23         1.40    85.02
Slatters Oniscidae                     1.00           0.63     0.61      1.14         1.38    86.40
Beetles Dytiscidae                     0.57           0.80     0.56      1.07         1.28    87.67
Caddisfly larvae Leptoceridae          0.11           0.89     0.50      0.90         1.12    88.80
Snails Lymnaeidae                      0.86           0.35     0.48      1.63         1.08    89.88
True Fly larvae Ceratopogonidae        0.79           0.00     0.45      0.62         1.03    90.91
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Groups Buffalo Ck & Porters Ck

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Average dissimilarity = 38.00

                                     Group Buffalo Ck   Group Porters Ck
Species                              Av.Abund       Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Chironominae        10.08           9.60     2.10      1.24         5.53     5.53
Snails Physidae                          7.20           4.96     1.92      1.37         5.04    10.57
True Fly larvae s-f Orthocladiinae       2.08           2.90     1.67      1.26         4.39    14.97
True bugs Notonectidae                   5.22           3.39     1.63      1.55         4.30    19.27
Dragonfly larvae Isostictidae            2.41           4.47     1.57      1.44         4.14    23.41
Snails Hydrobiidae                       5.96           8.43     1.55      1.19         4.09    27.49
Dragonfly larvae Hemicorduliidae         3.27           2.94     1.45      1.42         3.82    31.31
Dragonfly larvae Coenagrionidae          3.05           3.80     1.42      1.34         3.75    35.06
Caddisfly larvae Hydroptilidae           2.66           1.36     1.40      1.31         3.69    38.75
True Fly larvae s-f Tanypodinae          2.42           3.06     1.22      1.34         3.22    41.97
Leeches Glossiphoniidae                  1.16           2.26     1.20      1.24         3.16    45.13
Fairy shrimps Atyidae                    0.00           2.04     1.19      1.04         3.13    48.27
Dragonfly larvae Libellulidae            2.58           2.52     1.17      1.35         3.08    51.34
Flatworms Dugesiidae                     3.66           2.04     1.10      1.47         2.90    54.24
Worms Oligochaeta                        4.32           4.70     1.10      1.12         2.89    57.13
Dragonfly larvae Aeshnidae               1.75           1.22     1.02      1.27         2.70    59.83
Mussels Corbiculidae                     1.56           0.31     1.01      0.84         2.67    62.50
Snails Lymnaeidae                        1.80           0.35     0.97      1.45         2.56    65.06
Snails Planorbidae                       2.84           2.27     0.95      1.79         2.50    67.56
Dragonfly larvae Megapodagrionidae       5.19           5.00     0.94      1.33         2.47    70.03
Mussels Sphaeriidae                      1.54           0.72     0.89      1.22         2.33    72.36
Snails Ancylidae                         0.25           1.30     0.73      1.14         1.93    74.29
True Fly larvae Stratiomyidae            1.74           1.80     0.71      1.20         1.87    76.16
Mayfly larvae Baetidae                   1.11           0.25     0.66      0.69         1.73    77.89
Aquatic mites Acarina                    0.88           0.73     0.58      1.14         1.54    79.43
True Fly larvae Culicidae                0.92           0.52     0.55      1.15         1.44    80.88
Slatters Oniscidae                       0.88           0.63     0.53      0.99         1.39    82.27
True bugs Corixidae                      0.38           0.73     0.52      0.79         1.37    83.64
True bugs Gerridae                       0.86           0.38     0.52      1.21         1.36    84.99
Caddisfly larvae Leptoceridae            0.13           0.89     0.51      0.90         1.35    86.34
Beetles Dytiscidae                       0.18           0.80     0.51      0.81         1.34    87.68
True bugs Veliidae                       0.71           0.52     0.48      1.10         1.28    88.96
Sand hoppers Ceinidae                    0.61           0.25     0.47      0.65         1.24    90.20
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Groups Archers Ck & Shrimptons Ck

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Average dissimilarity = 48.92

                                     Group Archers Ck   Group Shrimptons Ck
Species                                 Av.Abund     Av.Abund Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Chironominae           11.54         5.83    4.74      1.44         9.69     9.69
True Fly larvae s-f Orthocladiinae          3.94         0.65    2.34      1.11         4.79    14.48
Snails Hydrobiidae                          3.86         0.93    2.29      1.46         4.68    19.16
Caddisfly larvae Hydroptilidae              2.74         0.57    1.76      0.98         3.61    22.77
Dragonfly larvae Libellulidae               3.89         1.42    1.75      1.32         3.58    26.35
True bugs Veliidae                          2.88         0.71    1.74      1.52         3.56    29.91
Snails Physidae                             5.89         7.32    1.73      1.37         3.54    33.46
True bugs Notonectidae                      3.08         2.26    1.57      1.33         3.20    36.66
Flatworms Dugesiidae                        5.42         6.33    1.54      1.24         3.15    39.81
Dragonfly larvae Megapodagrionidae          3.06         2.20    1.54      1.31         3.15    42.96
Dragonfly larvae Hemicorduliidae            3.50         2.59    1.52      1.43         3.12    46.07
True Fly larvae s-f Tanypodinae             3.11         1.12    1.45      1.62         2.97    49.04
Leeches Glossiphoniidae                     2.03         2.85    1.43      1.36         2.92    51.96
Snails Planorbidae                          0.00         2.08    1.42      1.12         2.91    54.87
Dragonfly larvae Aeshnidae                  2.07         0.56    1.36      1.18         2.78    57.65
Aquatic mites Acarina                       1.45         3.02    1.35      1.43         2.75    60.40
Dragonfly larvae Coenagrionidae             3.44         3.19    1.25      1.28         2.55    62.96
True Fly larvae Culicidae                   1.82         0.46    1.25      0.98         2.55    65.51
Mussels Corbiculidae                        0.38         1.51    1.21      0.83         2.48    67.98
Worms Oligochaeta                           6.55         5.29    1.16      1.15         2.38    70.36
Fairy shrimps Atyidae                       1.51         0.00    1.09      0.73         2.22    72.58
Mayfly larvae Baetidae                      1.57         0.27    1.03      0.79         2.10    74.69
True Fly larvae Stratiomyidae               2.32         0.92    1.01      1.52         2.07    76.75
Dragonfly larvae Isostictidae               0.00         1.50    0.92      0.85         1.87    78.63
True bugs Corixidae                         1.04         0.97    0.86      1.07         1.76    80.39
Mussels Sphaeriidae                         0.89         0.87    0.85      0.87         1.73    82.13
True Fly larvae Simuliidae                  1.24         0.00    0.78      1.04         1.60    83.72
True Fly larvae Tipulidae                   1.08         0.00    0.70      1.04         1.44    85.16
Slatters Oniscidae                          1.00         0.65    0.67      1.10         1.38    86.54
Snails Ancylidae                            0.62         0.73    0.66      0.79         1.34    87.88
Yabbies Parastacidae                        0.00         0.96    0.62      1.22         1.27    89.15
Dragonfly larvae Lestidae                   0.60         0.42    0.56      0.73         1.15    90.30
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Groups Buffalo Ck & Shrimptons Ck

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Average dissimilarity = 46.85

                                      Group Buffalo Ck  Group Shrimptons Ck
Species                               Av.Abund     Av.Abund Av.Diss  Diss/SD    Contrib%    Cum.%
True Fly larvae s-f Chironominae         10.08         5.83    4.09     1.53        8.74     8.74
Snails Hydrobiidae                        5.96         0.93    3.67     2.05        7.84    16.57
Dragonfly larvae Megapodagrionidae        5.19         2.20    2.37     1.61        5.06    21.63
True bugs Notonectidae                    5.22         2.26    2.35     1.53        5.01    26.64
Flatworms Dugesiidae                      3.66         6.33    1.99     1.51        4.24    30.89
Leeches Glossiphoniidae                   1.16         2.85    1.74     1.28        3.72    34.61
Caddisfly larvae Hydroptilidae            2.66         0.57    1.69     1.26        3.62    38.22
Aquatic mites Acarina                     0.88         3.02    1.63     1.59        3.48    41.70
Snails Physidae                           7.20         7.32    1.62     1.39        3.45    45.15
Worms Oligochaeta                         4.32         5.29    1.57     1.42        3.36    48.51
Dragonfly larvae Hemicorduliidae          3.27         2.59    1.57     1.40        3.34    51.86
Dragonfly larvae Coenagrionidae           3.05         3.19    1.48     1.45        3.17    55.02
Mussels Corbiculidae                      1.56         1.51    1.48     0.92        3.15    58.17
Snails Planorbidae                        2.84         2.08    1.44     1.49        3.07    61.25
Dragonfly larvae Isostictidae             2.41         1.50    1.38     1.48        2.95    64.19
True Fly larvae s-f Orthocladiinae        2.08         0.65    1.31     1.01        2.80    66.99
Dragonfly larvae Libellulidae             2.58         1.42    1.24     1.35        2.66    69.65
True Fly larvae s-f Tanypodinae           2.42         1.12    1.19     1.49        2.55    72.19
Dragonfly larvae Aeshnidae                1.75         0.56    1.12     1.17        2.39    74.58
Mussels Sphaeriidae                       1.54         0.87    1.01     1.19        2.16    76.74
Snails Lymnaeidae                         1.80         1.35    0.89     1.50        1.90    78.64
True Fly larvae Stratiomyidae             1.74         0.92    0.83     1.38        1.76    80.41
Mayfly larvae Baetidae                    1.11         0.27    0.74     0.68        1.57    81.98
True Fly larvae Culicidae                 0.92         0.46    0.73     1.16        1.56    83.54
True bugs Veliidae                        0.71         0.71    0.69     0.95        1.47    85.01
Yabbies Parastacidae                      0.00         0.96    0.65     1.22        1.38    86.39
True bugs Corixidae                       0.38         0.97    0.62     0.98        1.32    87.70
True bugs Gerridae                        0.86         0.46    0.59     1.09        1.26    88.97
Slatters Oniscidae                        0.88         0.65    0.58     0.96        1.25    90.21
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Groups Porters Ck & Shrimptons Ck

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Average dissimilarity = 51.11

                                      Group Porters Ck  Group Shrimptons Ck
Species                               Av.Abund    Av.Abund  Av.Diss  Diss/SD    Contrib%    Cum.%
Snails Hydrobiidae                        8.43        0.93     5.34     4.07       10.45    10.45
True Fly larvae s-f Chironominae          9.60        5.83     4.21     1.33        8.24    18.69
Flatworms Dugesiidae                      2.04        6.33     3.13     2.29        6.12    24.81
Dragonfly larvae Isostictidae             4.47        1.50     2.42     1.60        4.74    29.55
Dragonfly larvae Megapodagrionidae        5.00        2.20     2.37     1.51        4.63    34.19
Snails Physidae                           4.96        7.32     1.98     1.39        3.88    38.06
True Fly larvae s-f Orthocladiinae        2.90        0.65     1.84     1.20        3.60    41.66
True Fly larvae s-f Tanypodinae           3.06        1.12     1.71     1.32        3.35    45.01
Aquatic mites Acarina                     0.73        3.02     1.64     1.56        3.21    48.22
Leeches Glossiphoniidae                   2.26        2.85     1.59     1.27        3.10    51.32
True bugs Notonectidae                    3.39        2.26     1.56     1.34        3.05    54.37
Dragonfly larvae Hemicorduliidae          2.94        2.59     1.54     1.43        3.01    57.38
Dragonfly larvae Coenagrionidae           3.80        3.19     1.38     1.45        2.71    60.09
Fairy shrimps Atyidae                     2.04        0.00     1.36     1.04        2.65    62.74
Mussels Corbiculidae                      0.31        1.51     1.26     0.77        2.47    65.21
Worms Oligochaeta                         4.70        5.29     1.21     1.41        2.37    67.58
Snails Planorbidae                        2.27        2.08     1.20     1.60        2.34    69.92
Dragonfly larvae Libellulidae             2.52        1.42     1.13     1.35        2.22    72.14
Caddisfly larvae Hydroptilidae            1.36        0.57     1.00     1.02        1.96    74.10
Snails Ancylidae                          1.30        0.73     0.95     1.17        1.86    75.96
True Fly larvae Stratiomyidae             1.80        0.92     0.91     1.20        1.77    77.73
Dragonfly larvae Aeshnidae                1.22        0.56     0.87     0.99        1.71    79.44
Snails Lymnaeidae                         0.35        1.35     0.82     1.44        1.60    81.03
True bugs Corixidae                       0.73        0.97     0.80     1.02        1.56    82.60
Mussels Sphaeriidae                       0.72        0.87     0.66     1.11        1.30    83.89
Yabbies Parastacidae                      0.00        0.96     0.65     1.22        1.28    85.17
True bugs Veliidae                        0.52        0.71     0.63     0.85        1.23    86.40
Caddisfly larvae Leptoceridae             0.89        0.00     0.58     0.87        1.13    87.53
Beetles Dytiscidae                        0.80        0.11     0.56     0.78        1.10    88.63
True Fly larvae Culicidae                 0.52        0.46     0.51     0.84        1.00    89.63
Slatters Oniscidae                        0.63        0.65     0.50     1.10        0.98    90.62
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Groups Archers Ck  &  Terrys Ck
Average dissimilarity = 43.17

                                     Group Archers Ck    Group Terrys Ck
Species                                 Av.Abund    Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Chironominae           11.54        7.25     3.01      1.40         6.98     6.98
Dragonfly larvae Megapodagrionidae          3.06        8.16     2.82      3.58         6.53    13.51
Snails Hydrobiidae                          3.86        8.24     2.65      1.30         6.13    19.64
Dragonfly larvae Isostictidae               0.00        3.92     2.16      4.38         5.01    24.65
True Fly larvae s-f Orthocladiinae          3.94        1.96     1.73      1.19         4.01    28.66
Caddisfly larvae Hydroptilidae              2.74        0.84     1.46      1.11         3.39    32.05
Dragonfly larvae Libellulidae               3.89        1.93     1.44      1.28         3.34    35.40
Dragonfly larvae Hemicorduliidae            3.50        4.26     1.35      1.42         3.13    38.52
True bugs Notonectidae                      3.08        3.92     1.33      1.25         3.08    41.61
Mussels Sphaeriidae                         0.89        2.02     1.24      1.31         2.87    44.48
Flatworms Dugesiidae                        5.42        5.07     1.22      1.77         2.82    47.31
Snails Physidae                             5.89        5.98     1.16      1.41         2.70    50.00
Snails Planorbidae                          0.00        2.13     1.16      2.01         2.69    52.69
Dragonfly larvae Coenagrionidae             3.44        2.40     1.10      1.18         2.55    55.24
Beetles Elmidae                             0.16        2.05     1.05      2.71         2.44    57.68
True Fly larvae Culicidae                   1.82        0.79     1.05      1.05         2.43    60.11
Mussels Corbiculidae                        0.38        1.75     0.99      0.92         2.29    62.39
Worms Oligochaeta                           6.55        5.37     0.98      1.54         2.27    64.66
Dragonfly larvae Aeshnidae                  2.07        0.89     0.97      1.20         2.24    66.90
True Fly larvae s-f Tanypodinae             3.11        4.48     0.93      1.44         2.16    69.06
Fairy shrimps Atyidae                       1.51        0.00     0.89      0.74         2.07    71.12
Mayfly larvae Baetidae                      1.57        0.18     0.85      0.77         1.98    73.10
Aquatic mites Acarina                       1.45        2.10     0.80      1.61         1.86    74.97
Leeches Glossiphoniidae                     2.03        1.73     0.80      1.48         1.84    76.81
True bugs Gerridae                          0.27        1.59     0.79      1.51         1.84    78.65
True bugs Veliidae                          2.88        2.11     0.69      1.01         1.61    80.26
True Fly larvae Simuliidae                  1.24        0.91     0.66      1.16         1.53    81.79
True Fly larvae Ceratopogonidae             0.79        0.80     0.62      1.00         1.45    83.24
True bugs Corixidae                         1.04        0.28     0.62      0.81         1.43    84.67
True Fly larvae Tipulidae                   1.08        0.93     0.58      1.31         1.34    86.01
Slatters Oniscidae                          1.00        0.38     0.55      1.01         1.28    87.29
Sand hoppers Talitridae                     0.00        0.87     0.50      1.22         1.17    88.46
True bugs Gelastocoridae                    0.16        0.89     0.48      1.40         1.12    89.58
Snails Ancylidae                            0.62        0.40     0.47      0.74         1.08    90.66

Groups Buffalo Ck  &  Terrys Ck

Average dissimilarity = 36.66

                                     Group Buffalo Ck    Group Terrys Ck
Species                                 Av.Abund    Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Chironominae           10.08        7.25     2.34      1.36         6.39     6.39
Dragonfly larvae Megapodagrionidae          5.19        8.16     1.74      2.10         4.75    11.14
Dragonfly larvae Hemicorduliidae            3.27        4.26     1.53      1.38         4.18    15.32
Snails Hydrobiidae                          5.96        8.24     1.48      1.27         4.04    19.36
True bugs Notonectidae                      5.22        3.92     1.48      1.37         4.02    23.39
Snails Physidae                             7.20        5.98     1.39      1.51         3.78    27.17
True Fly larvae s-f Tanypodinae             2.42        4.48     1.28      1.34         3.50    30.67
Caddisfly larvae Hydroptilidae              2.66        0.84     1.25      1.25         3.42    34.09
Mussels Corbiculidae                        1.56        1.75     1.21      0.97         3.31    37.40
Dragonfly larvae Coenagrionidae             3.05        2.40     1.20      1.43         3.27    40.67
Beetles Elmidae                             0.00        2.05     1.16      3.64         3.17    43.84
Worms Oligochaeta                           4.32        5.37     1.14      1.29         3.11    46.95
Dragonfly larvae Libellulidae               2.58        1.93     1.12      1.35         3.04    50.00
True Fly larvae s-f Orthocladiinae          2.08        1.96     1.09      1.30         2.99    52.98
Dragonfly larvae Isostictidae               2.41        3.92     1.09      1.55         2.98    55.96
Mussels Sphaeriidae                         1.54        2.02     1.04      1.29         2.84    58.80
Snails Planorbidae                          2.84        2.13     0.97      1.43         2.65    61.45
Flatworms Dugesiidae                        3.66        5.07     0.95      1.37         2.58    64.04
Aquatic mites Acarina                       0.88        2.10     0.91      1.60         2.48    66.51
Dragonfly larvae Aeshnidae                  1.75        0.89     0.87      1.41         2.37    68.88
True bugs Veliidae                          0.71        2.11     0.86      1.77         2.35    71.23
Snails Lymnaeidae                           1.80        0.85     0.85      1.52         2.32    73.54
Leeches Glossiphoniidae                     1.16        1.73     0.80      1.46         2.19    75.73
True bugs Gerridae                          0.86        1.59     0.72      1.29         1.97    77.70
True Fly larvae Culicidae                   0.92        0.79     0.65      1.11         1.78    79.48
Mayfly larvae Baetidae                      1.11        0.18     0.61      0.65         1.66    81.14
Sand hoppers Ceinidae                       0.61        0.60     0.54      0.77         1.47    82.61
True Fly larvae Tipulidae                   0.13        0.93     0.51      1.17         1.39    84.00
True Fly larvae Simuliidae                  0.13        0.91     0.50      0.99         1.37    85.37
Sand hoppers Talitridae                     0.13        0.87     0.50      1.21         1.37    86.74
True Fly larvae Stratiomyidae               1.74        1.85     0.49      1.20         1.35    88.09
True Fly larvae Ceratopogonidae             0.68        0.80     0.48      1.08         1.30    89.39
Slatters Oniscidae                          0.88        0.38     0.47      0.88         1.27    90.67
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Groups Porters Ck  &  Terrys Ck
Average dissimilarity = 37.76

                                       Group Porters Ck   Group Terrys Ck
Species                                Av.Abund    Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
True Fly larvae s-f Chironominae           9.60        7.25     2.57      1.18         6.82     6.82
Dragonfly larvae Megapodagrionidae         5.00        8.16     1.87      1.86         4.94    11.76
Flatworms Dugesiidae                       2.04        5.07     1.76      2.10         4.67    16.43
Dragonfly larvae Hemicorduliidae           2.94        4.26     1.57      1.37         4.16    20.59
True Fly larvae s-f Orthocladiinae         2.90        1.96     1.32      1.45         3.50    24.09
True bugs Notonectidae                     3.39        3.92     1.31      1.54         3.46    27.55
True Fly larvae s-f Tanypodinae            3.06        4.48     1.26      1.46         3.33    30.88
Dragonfly larvae Coenagrionidae            3.80        2.40     1.23      1.34         3.25    34.13
Snails Physidae                            4.96        5.98     1.18      1.29         3.13    37.26
Beetles Elmidae                            0.00        2.05     1.18      3.73         3.11    40.37
Fairy shrimps Atyidae                      2.04        0.00     1.13      1.04         2.99    43.36
Dragonfly larvae Isostictidae              4.47        3.92     1.12      1.55         2.98    46.33
Mussels Sphaeriidae                        0.72        2.02     1.10      1.34         2.91    49.25
Dragonfly larvae Libellulidae              2.52        1.93     1.04      1.36         2.76    52.01
Mussels Corbiculidae                       0.31        1.75     1.00      0.85         2.66    54.67
Leeches Glossiphoniidae                    2.26        1.73     0.98      1.41         2.61    57.28
Snails Hydrobiidae                         8.43        8.24     0.94      1.47         2.49    59.77
True bugs Veliidae                         0.52        2.11     0.94      1.87         2.49    62.26
Aquatic mites Acarina                      0.73        2.10     0.88      1.71         2.33    64.60
Worms Oligochaeta                          4.70        5.37     0.84      1.36         2.22    66.82
True bugs Gerridae                         0.38        1.59     0.81      1.52         2.14    68.96
Caddisfly larvae Hydroptilidae             1.36        0.84     0.79      1.23         2.08    71.05
Snails Ancylidae                           1.30        0.40     0.73      1.18         1.93    72.97
Snails Planorbidae                         2.27        2.13     0.65      1.33         1.71    74.68
Dragonfly larvae Aeshnidae                 1.22        0.89     0.63      1.06         1.67    76.36
True Fly larvae Culicidae                  0.52        0.79     0.55      0.85         1.45    77.81
True bugs Gelastocoridae                   0.00        0.89     0.52      1.45         1.38    79.19
True Fly larvae Simuliidae                 0.13        0.91     0.51      0.99         1.35    80.54
True Fly larvae Tipulidae                  0.52        0.93     0.51      1.25         1.34    81.88
True Fly larvae Stratiomyidae              1.80        1.85     0.51      1.08         1.34    83.22
True bugs Corixidae                        0.73        0.28     0.51      0.73         1.34    84.56
Beetles Dytiscidae                         0.80        0.25     0.49      0.89         1.30    85.86
Sand hoppers Talitridae                    0.25        0.87     0.49      1.23         1.28    87.15
Caddisfly larvae Leptoceridae              0.89        0.00     0.48      0.86         1.28    88.43
Snails Lymnaeidae                          0.35        0.85     0.48      1.19         1.28    89.70
True Fly larvae Ceratopogonidae            0.00        0.80     0.47      0.83         1.25    90.95

Groups Shrimptons Ck  &  Terrys Ck
Average dissimilarity = 47.05

                                       Group Shrimptons Ck   Group Terrys Ck
Species                                Av.Abund    Av.Abund  Av.Diss   Diss/SD     Contrib%    Cum.%
Snails Hydrobiidae                         0.93        8.24     4.88      3.36        10.37    10.37
Dragonfly larvae Megapodagrionidae         2.20        8.16     4.02      2.32         8.55    18.92
True Fly larvae s-f Chironominae           5.83        7.25     3.01      1.45         6.40    25.33
True Fly larvae s-f Tanypodinae            1.12        4.48     2.21      2.13         4.70    30.03
Dragonfly larvae Isostictidae              1.50        3.92     1.90      1.88         4.04    34.07
Dragonfly larvae Hemicorduliidae           2.59        4.26     1.77      1.41         3.76    37.83
True bugs Notonectidae                     2.26        3.92     1.74      1.34         3.71    41.54
Mussels Corbiculidae                       1.51        1.75     1.45      0.95         3.08    44.61
Leeches Glossiphoniidae                    2.85        1.73     1.36      1.38         2.90    47.51
Beetles Elmidae                            0.00        2.05     1.32      3.68         2.81    50.32
Snails Physidae                            7.32        5.98     1.30      1.40         2.77    53.09
True bugs Veliidae                         0.71        2.11     1.24      2.32         2.63    55.72
Mussels Sphaeriidae                        0.87        2.02     1.23      1.30         2.61    58.33
Snails Planorbidae                         2.08        2.13     1.16      1.43         2.47    60.80
Dragonfly larvae Coenagrionidae            3.19        2.40     1.14      1.41         2.42    63.22
Flatworms Dugesiidae                       6.33        5.07     1.12      1.22         2.39    65.61
Aquatic mites Acarina                      3.02        2.10     1.07      1.30         2.27    67.88
Worms Oligochaeta                          5.29        5.37     1.06      1.33         2.24    70.12
Dragonfly larvae Libellulidae              1.42        1.93     0.91      1.34         1.93    72.04
True bugs Gerridae                         0.46        1.59     0.89      1.42         1.90    73.94
True Fly larvae s-f Orthocladiinae         0.65        1.96     0.87      1.31         1.85    75.79
True Fly larvae Stratiomyidae              0.92        1.85     0.72      1.45         1.53    77.32
Caddisfly larvae Hydroptilidae             0.57        0.84     0.68      1.21         1.44    78.76
True bugs Corixidae                        0.97        0.28     0.64      1.00         1.37    80.13
Snails Lymnaeidae                          1.35        0.85     0.64      1.14         1.36    81.48
True Fly larvae Culicidae                  0.46        0.79     0.63      0.75         1.34    82.83
Yabbies Parastacidae                       0.96        0.00     0.61      1.22         1.29    84.12
True Fly larvae Tipulidae                  0.00        0.93     0.60      1.18         1.28    85.39
Sand hoppers Talitridae                    0.00        0.87     0.60      1.21         1.27    86.66
Dragonfly larvae Aeshnidae                 0.56        0.89     0.58      1.29         1.24    87.90
Snails Ancylidae                           0.73        0.40     0.57      0.80         1.20    89.11
True Fly larvae Simuliidae                 0.00        0.91     0.56      0.92         1.20    90.30
```

SIMPER Archers Creek 2005, 2006, 2007, 2008 and 2009

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

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

Factor Groups
Sample   Season Year
S5       Autumn 2005
S5       Spring 2005
S5       Autumn 2006
S5       Spring 2006
S5       Autumn 2007
S5       Spring 2007
S5       Autumn 2008
S5       Spring 2008
S5       Autumn 2009

Group Autumn 2005
Average similarity: 68.02

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

Group Spring 2005
Average similarity: 58.85

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

Group Autumn 2006
Average similarity: 72.35

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

Group Spring 2006

```
Average similarity: 60.22

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae              4.35     14.93     4.12      24.80    24.80
Snails Physidae                               2.81     10.04     3.55      16.68    41.47
Flatworms Dugesiidae                          2.63      8.66     2.75      14.39    55.86
Worms Oligochaeta                             2.43      7.87     2.82      13.07    68.93
Snails Hydrobiidae                            1.81      4.51     1.47       7.48    76.41
True Fly larvae s-f Tanypodinae               1.07      3.38     1.76       5.62    82.03
True bugs Veliidae                            0.80      1.96     0.79       3.25    85.28
True Fly larvae s-f Orthocladiinae            1.06      1.92     0.79       3.18    88.47
True Fly larvae Stratiomyidae                 0.87      1.55     0.57       2.58    91.05
```

Group Autumn 2007

```
Average similarity: 57.33

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

Group Spring 2007

```
Average similarity: 61.15

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae              5.57     14.94     7.60      24.43    24.43
Snails Physidae                               3.77     10.20     7.13      16.67    41.10
Snails Hydrobiidae                            2.81      6.69     2.42      10.94    52.04
Worms Oligochaeta                             2.95      6.47     3.33      10.58    62.62
Flatworms Dugesiidae                          2.70      4.97     1.23       8.13    70.76
True Fly larvae s-f Tanypodinae               1.84      3.95     2.50       6.46    77.22
Mussels Sphaeriidae                           2.01      3.08     1.02       5.04    82.26
Dragonfly larvae Hemicorduliidae              1.57      2.37     1.15       3.88    86.14
Dragonfly larvae Libellulidae                 1.04      2.14     1.29       3.50    89.63
True Fly larvae s-f Orthocladiinae            1.33      1.78     0.73       2.91    92.55
```

Group Autumn 2008

```
Average similarity: 61.49

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Orthocladiinae            4.42     13.77     5.31      22.39    22.39
True Fly larvae s-f Chironominae              3.35     10.77     5.75      17.51    39.91
Snails Hydrobiidae                            2.52      7.04     2.73      11.45    51.35
Worms Oligochaeta                             1.69      5.05     3.62       8.21    59.56
True bugs Veliidae                            1.62      4.32     4.25       7.03    66.59
Snails Physidae                               2.03      4.28     1.16       6.96    73.55
True bugs Notonectidae                        1.69      3.42     1.06       5.56    79.10
Caddisfly larvae Hydroptilidae                1.35      2.21     0.74       3.59    82.69
True Fly larvae Ceratopogonidae               1.15      2.07     0.78       3.36    86.05
Mayfly larvae Baetidae                        1.26      1.64     0.48       2.66    88.72
True Fly larvae Stratiomyidae                 0.67      1.43     0.79       2.33    91.05
```

Group Spring 2008

```
Average similarity: 69.72

Species                                   Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae              3.99     12.17    10.20      17.46    17.46
Flatworms Dugesiidae                          2.87      8.16     7.17      11.70    29.16
Worms Oligochaeta                             2.85      8.05     6.36      11.55    40.71
Caddisfly larvae Hydroptilidae                3.13      7.69     3.78      11.04    51.75
Snails Physidae                               2.77      6.64     2.38       9.53    61.28
Snails Hydrobiidae                            2.46      6.11     5.80       8.77    70.04
True Fly larvae s-f Orthocladiinae            2.49      4.74     1.09       6.80    76.84
True bugs Notonectidae                        1.74      3.20     1.03       4.58    81.43
Snails Ancylidae                              1.30      2.59     1.31       3.72    85.15
True Fly larvae s-f Tanypodinae               1.24      2.29     1.29       3.29    88.43
Leeches Glossiphoniidae                       1.08      2.28     1.24       3.27    91.70
```

```
Group Autumn 2009
Average similarity: 64.32

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae               4.02     10.17     4.55      15.81    15.81
Dragonfly larvae Libellulidae                  3.11      6.61     2.09      10.27    26.08
Flatworms Dugesiidae                           2.69      6.32     2.12       9.83    35.91
Caddisfly larvae Hydroptilidae                 2.52      5.85     2.36       9.10    45.00
Worms Oligochaeta                              2.33      5.20     3.07       8.08    53.08
True Fly larvae s-f Orthocladiinae             2.16      4.81     2.62       7.49    60.57
Snails Physidae                                2.02      4.29     2.49       6.67    67.24
True Fly larvae Simuliidae                     1.57      3.61     3.93       5.61    72.85
Dragonfly larvae Coenagrionidae                1.77      3.55     3.75       5.52    78.37
Snails Hydrobiidae                             2.04      3.06     1.17       4.76    83.13
True bugs Notonectidae                         1.78      2.08     0.73       3.23    86.36
True Fly larvae Ceratopogonidae                0.97      1.85     1.34       2.87    89.23
Leeches Glossiphoniidae                        1.22      1.55     0.77       2.41    91.64
```

SIMPER Shrimptons Creek 2005, 2006, 2007, 2008 and 2009

```
Data worksheet
Name: Shtimptons Sqrt
Data type: Abundance
Sample selection: All
Variable selection: All

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

Factor Groups
Sample  Season Year
S2      Autumn 2005
S2      Spring 2005
S2      Autumn 2006
S2      Spring 2006
S2      Autumn 2007
S2      Spring 2007
S2      Autumn 2008
S2      Spring 2008
S2      Autumn 2009

Group Autumn 2005
Average similarity: 75.89

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

Group Spring 2005
Average similarity: 76.54

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

Group Autumn 2006
Average similarity: 76.70

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

Group Spring 2006
Average similarity: 62.17

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

Group Autumn 2007

```
Average similarity: 60.39

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

Group Spring 2007

```
Average similarity: 63.13

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

Group Autumn 2008

```
Average similarity: 57.63

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Flatworms Dugesiidae                           3.55     20.83     4.34      36.15    36.15
Snails Physidae                                2.91     16.00     4.67      27.76    63.91
Worms Oligochaeta                              1.52      6.57     1.29      11.39    75.30
Dragonfly larvae Megapodagrionidae             1.05      3.47     0.77       6.02    81.32
Leeches Glossiphoniidae                        1.22      2.81     0.76       4.87    86.19
Aquatic mites Acarina                          0.98      2.63     0.78       4.57    90.76
```

Group Spring 2008

```
Average similarity: 62.97

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%     Cum.%
Snails Physidae                                3.46     15.55     5.33      24.69     24.69
Flatworms Dugesiidae                           2.86     12.16     5.11      19.31     44.00
True Fly larvae s-f Chironominae               2.37      9.80     3.96      15.56     59.56
Worms Oligochaeta                              2.02      7.51     2.08      11.93     71.48
Dragonfly larvae Coenagrionidae                1.95      6.57     2.85      10.43     81.91
Aquatic mites Acarina                          1.41      2.94     0.78       4.66     86.58
Leeches Glossiphoniidae                        0.98      2.04     0.77       3.24     89.82
Mussels Sphaeriidae                            0.79      1.84     0.78       2.92     92.73
```

Group Autumn 2009

```
Average similarity: 48.10

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%     Cum.%
Flatworms Dugesiidae                           2.87     15.22     5.70      31.64     31.64
Leeches Glossiphoniidae                        1.62      7.41     1.34      15.41     47.05
True bugs Notonectidae                         1.50      5.22     1.18      10.86     57.91
Snails Lymnaeidae                              1.09      4.86     1.30      10.10     68.01
Snails Physidae                                1.45      4.82     0.72      10.02     78.03
Dragonfly larvae Coenagrionidae                1.16      3.69     0.76       7.68     85.71
True Fly larvae s-f Chironominae               1.07      3.50     0.69       7.29     92.99
```

SIMPER Buffalo Creek 2005, 2006, 2007, 2008 and 2009

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

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

Factor Groups
Sample  Season Year
S4      Autumn 2005
S4      Spring 2005
S4      Autumn 2006
S4      Autumn 2007
S4      Spring 2007
S4      Autumn 2008
S4      Spring 2008
S4      Autumn 2009

Group Autumn 2005
Average similarity: 76.18

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

Group Spring 2005
Average similarity: 66.97

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

Group Autumn 2006
Average similarity: 75.41

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

```
Group Autumn 2007
Average similarity: 69.52

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

Group Spring 2007
Average similarity: 65.17

Species                                    Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae               4.63     14.76      4.83      22.65    22.65
Snails Physidae                                3.92     14.38     11.29      22.07    44.72
Snails Hydrobiidae                             2.54      8.68      5.00      13.33    58.05
Dragonfly larvae Megapodagrionidae             1.97      5.33      2.53       8.17    66.22
Worms Oligochaeta                              1.68      5.09      2.75       7.81    74.03
True bugs Notonectidae                         1.43      4.64      4.77       7.12    81.15
Dragonfly larvae Isostictidae                  1.51      2.99      0.78       4.58    85.73
Dragonfly larvae Coenagrionidae                1.01      1.86      0.77       2.85    88.58
True Fly larvae s-f Tanypodinae                0.97      1.81      0.77       2.78    91.36

Group Autumn 2008
Average similarity: 63.54

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

Group Spring 2008
Average similarity: 66.36

Species                                    Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Physidae                                3.74     19.33      4.65      29.12    29.12
True Fly larvae s-f Chironominae               3.71     17.61      4.48      26.53    55.65
Snails Hydrobiidae                             3.12     15.91      3.89      23.97    79.62
Dragonfly larvae Megapodagrionidae             1.19      4.58      1.30       6.90    86.52
Worms Oligochaeta                              1.26      4.10      1.29       6.19    92.71

Group Autumn 2009
Average similarity: 68.72

Species                                    Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Physidae                                3.01      9.79      5.02      14.24    14.24
True Fly larvae s-f Chironominae               2.86      8.96      3.23      13.04    27.28
Snails Hydrobiidae                             2.97      8.61      3.50      12.53    39.81
True bugs Notonectidae                         2.35      7.03      3.56      10.23    50.04
Dragonfly larvae Megapodagrionidae             2.08      6.23      5.89       9.06    59.11
True Fly larvae s-f Orthocladiinae             1.54      4.90      3.79       7.14    66.24
Dragonfly larvae Coenagrionidae                1.63      4.57      4.41       6.65    72.90
Flatworms Dugesiidae                           1.67      3.69      1.31       5.36    78.26
Caddisfly larvae Hydroptilidae                 1.50      3.25      1.24       4.72    82.98
Snails Planorbidae                             1.55      3.02      0.78       4.39    87.38
Dragonfly larvae Isostictidae                  0.90      2.48      1.34       3.61    90.98
```

SIMPER Porters Creek 2005, 2006, 2007, 2008 and 2009

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

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

Factor Groups
Sample  Season Year
S3      Autumn 2005
S3      Spring 2005
S3      Autumn 2006
S3      Autumn 2007
S3      Spring 2007
S3      Autumn 2008
S3      Spring 2008
S3      Autumn 2009

Group Autumn 2005
Average similarity: 76.82

Species                                  Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae             6.51     12.89    10.12      16.78    16.78
Snails Hydrobiidae                           4.59      8.30     7.22      10.80    27.58
Dragonfly larvae Isostictidae                4.18      8.07    10.67      10.50    38.08
Dragonfly larvae Hemicorduliidae             2.89      5.93    55.42       7.71    45.80
Snails Physidae                              3.09      5.90    11.52       7.68    53.47
Dragonfly larvae Megapodagrionidae           3.01      5.40    10.58       7.03    60.50
Dragonfly larvae Coenagrionidae              2.83      4.64     2.61       6.04    66.54
Snails Planorbidae                           2.30      4.51     7.69       5.87    72.40
Worms Oligochaeta                            2.45      4.13     4.56       5.38    77.79
Leeches Glossiphoniidae                      2.10      3.54     3.45       4.61    82.40
True Fly larvae s-f Tanypodinae              2.39      3.38     4.51       4.40    86.79
Dragonfly larvae Aeshnidae                   1.41      2.96    55.42       3.86    90.65

Group Spring 2005
Average similarity: 72.69

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

Group Autumn 2006
Average similarity: 71.92

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

Group Autumn 2007

```
Average similarity: 71.28

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

Group Spring 2007

```
Average similarity: 67.64

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

Group Autumn 2008

```
Average similarity: 60.24

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

Group Spring 2008

```
Average similarity: 52.26

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Snails Physidae                                2.92     12.47     4.82      23.87    23.87
Worms Oligochaeta                              2.24      9.31     2.70      17.81    41.68
True Fly larvae s-f Chironominae               2.57      7.72     0.77      14.77    56.44
Snails Hydrobiidae                             2.22      6.22     1.09      11.90    68.35
True bugs Notonectidae                         1.26      4.09     1.34       7.82    76.17
Dragonfly larvae Megapodagrionidae             1.09      4.04     1.19       7.72    83.89
Snails Planorbidae                             1.00      3.25     1.33       6.23    90.12
```

Group Autumn 2009

```
Average similarity: 58.24

Species                                    Av.Abund    Av.Sim   Sim/SD   Contrib%    Cum.%
Snails Hydrobiidae                             3.36     13.95     5.78      23.95    23.95
True Fly larvae s-f Chironominae               3.22     12.90     5.48      22.15    46.10
True Fly larvae s-f Orthocladiinae             2.18      7.88     2.89      13.53    59.63
Dragonfly larvae Megapodagrionidae             1.59      5.08     1.32       8.72    68.36
Dragonfly larvae Coenagrionidae                1.30      3.40     1.31       5.83    74.19
Worms Oligochaeta                              1.07      3.25     1.32       5.58    79.77
True bugs Notonectidae                         1.21      2.64     0.79       4.53    84.30
Dragonfly larvae Isostictidae                  1.13      2.26     0.77       3.89    88.18
Caddisfly larvae Antipodoecidae                0.87      2.18     0.78       3.75    91.93
```

SIMPER Terrys Creek 2005, 2006, 2007, 2008 and 2009

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

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

Factor Groups
Sample  Season Year
S1      Autumn 2005
S1      Spring 2005
S1      Autumn 2006
S1      Autumn 2007
S1      Spring 2007
S1      Autumn 2008
S1      Spring 2008
S1      Autumn 2009

Group Autumn 2005
Average similarity: 69.53

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

Group Spring 2005
Average similarity: 64.98

Species                                 Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae            5.63     13.05     19.49      20.08    20.08
Snails Physidae                             3.14      6.76      7.02      10.41    30.49
Worms Oligochaeta                           3.17      6.51     11.44      10.02    40.52
Dragonfly larvae Megapodagrionidae          2.93      6.38     16.31       9.82    50.33
Dragonfly larvae Isostictidae               2.57      5.61      6.89       8.63    58.96
Mussels Corbiculidae                        2.05      3.57     12.60       5.50    64.46
True Fly larvae s-f Tanypodinae             2.26      3.50      1.77       5.38    69.84
Flatworms Dugesiidae                        1.52      3.33     20.76       5.13    74.97
Aquatic mites Acarina                       1.88      3.10      2.59       4.78    79.74
True bugs Notonectidae                      1.47      2.70      3.90       4.15    83.90
Dragonfly larvae Libellulidae               2.45      2.70      0.58       4.15    88.04
Snails Hydrobiidae                          2.35      2.48      0.58       3.82    91.86

Group Autumn 2006
Average similarity: 72.76

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

Group Autumn 2007

```
Average similarity: 65.81

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

Group Spring 2007

```
Average similarity: 64.85

Species                                  Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
True Fly larvae s-f Chironominae             4.77     14.86      7.37      22.92    22.92
Snails Hydrobiidae                           3.55     10.82      3.75      16.68    39.60
Dragonfly larvae Megapodagrionidae           2.98      8.85      4.52      13.66    53.26
Snails Physidae                              2.57      7.67      4.19      11.83    65.08
Flatworms Dugesiidae                         2.43      6.32      2.15       9.75    74.83
Worms Oligochaeta                            1.85      4.55      1.27       7.01    81.85
Dragonfly larvae Hemicorduliidae             1.52      2.87      1.21       4.42    86.27
True Fly larvae s-f Tanypodinae              1.00      2.33      1.35       3.60    89.87
Mussels Sphaeriidae                          1.12      1.98      0.73       3.06    92.93
```

Group Autumn 2008

```
Average similarity: 66.65

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

Group Spring 2008

```
Average similarity: 62.32

Species                                  Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Snails Hydrobiidae                           3.61     13.40      7.59      21.51    21.51
Snails Physidae                              3.19     11.41      6.79      18.30    39.81
Dragonfly larvae Megapodagrionidae           3.06     10.77      4.55      17.28    57.09
True Fly larvae s-f Chironominae             2.90      8.27      1.26      13.28    70.36
Worms Oligochaeta                            2.07      6.50      3.20      10.43    80.79
Flatworms Dugesiidae                         1.34      3.50      1.31       5.62    86.41
Mussels Sphaeriidae                          1.44      2.95      1.30       4.74    91.15
```

Group Autumn 2009

```
Average similarity: 62.72

Species                                  Av.Abund    Av.Sim    Sim/SD   Contrib%    Cum.%
Dragonfly larvae Megapodagrionidae           3.52     12.19      8.33      19.43    19.43
Snails Hydrobiidae                           3.60     11.94      5.12      19.05    38.48
True bugs Notonectidae                       2.00      5.86      2.85       9.34    47.82
Dragonfly larvae Isostictidae                1.71      5.12      3.87       8.16    55.98
Worms Oligochaeta                            1.55      4.73      5.04       7.53    63.51
Snails Physidae                              1.80      4.21      1.13       6.71    70.22
Flatworms Dugesiidae                         1.60      3.99      1.31       6.36    76.58
True Fly larvae s-f Tanypodinae              1.29      2.96      1.23       4.73    81.30
True bugs Gerridae                           0.74      1.55      0.79       2.48    83.78
Dragonfly larvae Coenagrionidae              0.94      1.46      0.78       2.34    86.12
Dragonfly larvae Hemicorduliidae             0.86      1.46      0.77       2.33    88.44
True Fly larvae s-f Chironominae             0.71      0.99      0.48       1.57    90.01
```

Appendix 6 BIOENV output

BIOENV of all five creeks with replicates merged for 2005, 2006, 2007, 2008 and 2009

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

Resemblance worksheet
Name: All creeks Resem1
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      5    0.437 4,9,12,17,21
      5    0.435 4,9,16,17,21
      5    0.431 9,12,16,17,21
      5    0.430 3,4,12,17,21
      5    0.429 3,12,16,17,21
      4    0.427 4,9,17,21
      3    0.427 12,17,21
      4    0.427 3,12,17,21
      4    0.423 4,12,17,21
      4    0.423 9,12,17,21
```

BIOENV of Archers Creek 2005, 2006, 2007, 2008 and 2009

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

Resemblance worksheet
Name: Achers Resemb1
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      3    0.352 3,7,8
      4    0.344 3,6-8
      5    0.341 3,4,7,8,12
      4    0.341 3,7,8,12
      5    0.338 3,4,6-8
      5    0.338 3,6-8,12
      5    0.335 3,4,6,7,12
      2    0.333 3,8
      5    0.332 3,6-8,11
      1    0.332 8
```

BIOENV of Shrimptons Creek 2005, 2006, 2007, 2008 and 2009

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

Resemblance worksheet
Name: Shrimptons Resem1
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      3    0.312 8,10,12
      2    0.303 8,10
      3    0.298 8,10,11
      4    0.298 8,10-12
      5    0.291 7,8,10-12
      5    0.290 8-12
      4    0.290 7,8,10,12
      4    0.289 8-10,12
      5    0.287 7-10,12
      5    0.285 7-11
```

BIOENV of Buffalo Creek 2005, 2006, 2007, 2008 and 2009

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

Resemblance worksheet
Name: buffalo
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      5    0.378 2,3,5,10,12
      4    0.376 2,3,10,12
      4    0.365 2,5,10,12
      4    0.361 2,3,5,12
      5    0.357 2,3,6,10,12
      5    0.355 2,3,5,6,12
      3    0.355 3,5,12
      5    0.354 2-4,10,12
      3    0.352 2,3,12
      5    0.350 2,3,7,10,12
```

BIOENV of Porters Creek 2005, 2006, 2007, 2008 and 2009

```
Data worksheet
Name: Porters WQ(2)
Data type: Environmental
Sample selection: All
Variable selection: All

Resemblance worksheet
Name: Porters Resem1
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      4    0.447 1,2,8,12
      4    0.443 1,5,8,12
      3    0.434 1,5,8
      3    0.432 1,8,12
      3    0.427 1,2,8
      5    0.426 1,2,5,8,12
      5    0.426 1,2,6,8,12
      2    0.426 8,12
      4    0.426 1,6,8,12
      5    0.425 1,5,6,8,12
```

BIOENV of Terrys Creek 2005, 2006, 2007, 2008

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

Resemblance worksheet
Name: Terrys Resem1
Data type: Similarity
Selection: All

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

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

Best results
No.Vars    Corr. Selections
      1    0.332 12
      2    0.330 6,12
      3    0.329 6,10,12
      3    0.324 5,10,12
      2    0.320 5,12
      4    0.317 3,5,10,12
      2    0.315 10,12
      4    0.315 5,6,10,12
      4    0.314 6,9,10,12
      3    0.312 3,5,12
```