Ecowise Environmental

FINAL REPORT

"Biological and Water Quality Monitoring of Five Core Sites in Autumn 2005"

Contract No. EP/WQM/E1/04

for

City of Ryde

September 2005

The management of water resources is an integral part of environmental management and an essential requirement for supporting the economic, social and environmental objectives of our society

September 2005

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Executive Summary

Urban streams (such as those affected by runoff and discharges from urban areas) are an important subset of Australia's waterways. Most are degraded biologically, physically and chemically and therefore require specialised methods for health assessment and management. It is within this context that the City of Ryde has initiated a 7 year Biological/Chemical Monitoring Strategy which focuses on biological and water quality monitoring of 5 key urban creek systems within its area of operations.

Ecowise Environmental was commissioned by the City of Ryde to conduct the first year of sampling as part of a 7 year Biological/Chemical Monitoring Strategy, and this report covers the second sampling event conducted in Autumn 2005. Core sampling sites were selected by Council and included sites on Terrys Ck, Shrimptons Ck, Porters Ck, Buffalo Ck and Archer Ck. Sampling was also conducted at two extra sites in Autumn 2005 due to site access problems experienced at two sites in Spring 2004.

Autumn sampling was conducted in March (30th & 31st), April (26th & 27th) and May (26rd & 27th). Sampling protocols defined in the "NSW Australian River Assessment System (AusRivAS) Sampling and Processing Manual, NSW EPA, July 2001" (Turak and Waddell, 2001) were adopted including physical and in-stream habitat descriptions. During each sampling event, water samples were collected and analysed for Total Dissolved solids, Total Phosphorus, Total Nitrogen, Ammonium, Total Alkalinity and Faecal Coliforms. In addition, an assessment of *in-situ* water quality was undertaken which included pH, Dissolved Oxygen, Electrical Conductivity, turbidity and water temperature.

A review of the water quality data indicated that dissolved oxygen concentrations regularly fell below the recommended ANZECC and ARMCANZ guideline value of 85% saturation across all sites for at least one sampling event in Autumn 2005. Conductivity in Porters Ck (Sites 3 and 6) was recorded above the ANZECC and ARMCANZ (2000) guideline for Aquatic Ecosystem health during the April and May sampling events. On both occasions the result was higher upstream at Site 3 than downstream at Site 6. Water temperature was the other significant result with a drop of at least 4°C at five of the seven sites between April and May sampling events.

A total of 47 aquatic macroinvertebrate families were recorded over the three Autumn sampling events, with insects the most dominant (26 taxa) followed by gastropods (4 taxa), and crustaceans (3 taxa).

Following the identification and enumeration of the macroinvertebrates samples, the data were analysed using a number of univariate and multivariate techniques, including AusRivAS modelling. Both types of techniques provide differing levels of information. Univariate indices concentrate mainly on assessing the condition or "health" of the sites, whilst multivariate analysis routines allow patterns (if any) between sites/samples to be identified (Classification and Ordination), the key taxa from each sample which may be contributing to these differences (SIMPER), and the isolation of

environmental variables that could be responsible for observed patterns (BVSTEP).

All sites within the City of Ryde study are indicative of urban creeks, with significant to severe impairment of ecological health. The main influences on these sites, and the creeks on which they are located, include poor water quality (exceeding recommended ANZECC and ARMCANZ, 2000 guidelines), and poor habitat diversity. Biodiversity and ecosystem health results from the Autumn 2005 sampling program are similar to those obtained in earlier monitoring programs, including the previous sampling program in Spring 2004. However, a comparison of results from Autumn 2002 to 2005 (Robyn Tuft and Associates and Ecowise) for Terrys Ck, Buffalo Ck and Porters Ck indicated an improvement in the ecological health of these creeks in 2005.

The Autumn 2005 sampling program has demonstrated that the design and methodology adopted for this project are appropriate to achieve the objectives of the City of Ryde program.

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1 INTRODUCTION

Urban streams are an important subset of Australia's waterways. Most are degraded biologically, physically and chemically and therefore require specialised methods for health assessment and management. The Urban Research and Development Program of the National River Health Program defines health in urban waterways as "the ability to support and maintain a balanced, integrative, adaptive community of organisms having a species composition, diversity and functional organisation as comparable as practicable to that of natural habitats of the region".

The increasing urbanisation of catchments results in four broad inter-related forms of disturbance or degradation that can affect stream ecology:

- Disturbance of hydrological and hydraulic patterns
- Disturbance to stream geomorphology
- Degradation of water quality, and
- Habitat degradation or simplification

We now recognise that the benefits we derive from our cities have come at a considerable environmental cost. Urbanisation and associated human activity has profoundly affected rivers and streams around the world and the importance of the links between stream health and human health is increasingly being recognised both internationally and nationally. Streams in urban areas have received relatively little scientific attention when compared with systems in natural (minimally disturbed) or rural areas.

1.1 Background

The City of Ryde recently approved a Biological/Chemical Water Quality Monitoring Strategy targeting 5 main creek systems within its area of operations. The program commenced in September 2004 and will be delivered over a 7 year period.

Shrimptons, Archer, Porters, Buffalo and Terrys Creeks have been targeted in this Strategy and it is proposed that one core monitoring site near the exit point of each of these creek systems be monitored within the terms of the Strategy.

The Strategy (COR Quotation No.: EP/WQM/E1/04) will enable the City of Ryde to:

- Evaluate chemical and biological water quality monitoring both for short and long term interpretation of creek health,
- 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 and accessibility,
- Prescribe how to sample macroinvertebrates at each site, 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 a standard suite of analyses to determine status and trends in water quality including calculation of the AusRivAS index,
- Provide the basis for an appraisal of the capacity of a standard monitoring program, eg. Streamwatch, and
- 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.

Ecowise Environmental was commissioned by City of Ryde to conduct the first year of sampling beginning in Spring 2004. This report covers the second sampling program for the Biological/Chemical Water Quality Monitoring Strategy in Autumn 2005.

1.2 Scope of Works

The scope of works for the Autumn 2005 sampling program, as specified in the project brief (Quotation No: EP/WQM/E1/04), included:

1. Measure aquatic macroinvertebrates and water chemistry at the 5 core sites selected by City of Ryde,
2. Sample in Autumn 2005 (March, April and May). Each site, as a minimum should be sampled once per month and sampling shall be undertaken strictly in accordance with NSW AusRivAS protocols,
3. Collect macroinvertebrates and chemical data at each core site,
4. Characterise each core site according to AusRivAS protocols for physico-chemical properties and sample the recommended chemical data,
5. Sample macroinvertebrates from the same 5 pool and riffle (if applicable) habitats at each core site,
6. Identify samples of macroinvertebrates to family level, and
7. Preserve specimens from selected families to allow for morphospecies identification if a SIGNAL2 was not apparent from the data collected at each geo-referenced point.

Additionally, sampling was conducted at two extra sites during the Autumn 2005 program. Due to issues of private property access and miscommunication in project brief, a misunderstanding regarding the exact location of two core sites during the Spring 2004 program led to Porters Ck and Buffalo Ck sites located a short distance from the historical core site locations

To provide an assessment of similarity, Ecowise collected macroinvertebrate samples at both the historical sites and the sites sampled by Ecowise in Porters Ck and Buffalo Ck during Spring 2004, at no cost to Council. Both historical sites are located downstream of Spring 2004 sites.

1.3 Historical sampling programs

A number of macroinvertebrate studies have previously been undertaken on the 5 core sites.

Shrimptons and Archer Creeks

- BioTrack (Dec, 2001) "Biological Water Quality Monitoring of Shrimptons and Archer Creeks, Ryde". Progress Report prepared for Ryde City Council.
- BioTrack (July, 2002) "Biological Water Quality Monitoring of Shrimptons and Archer Creeks, Ryde". Prepared for Ryde City Council.
- BioTrack (June, 2004) "Post restoration macroinvertebrate sampling of Archer Creek, Ryde". Prepared for Ryde City Council.

The BioTrack (2001; 2002) programs were designed to provide baseline biological water quality monitoring data to assist Ryde City Council in assessing the effectiveness of remediation works. Three sites were assessed, with two sites on Shrimptons Ck (one upstream and one downstream of the proposed remediation works) and one site on Archer Ck to be used as a benchmark. Samples were collected monthly between June 01 and May 02, using NSW AusRivAS protocols. The program results indicated both systems were typical of an urban creek environment, with abundant pollution tolerant taxa, and overall poor ecosystem health. This result was further enhanced by the post-restorative monitoring program conducted on Archer Ck at Maze Park by BioTrack (2004), with a dramatic reduction in taxa diversity when compared to the 2001 results. Several suggestions were thought to have caused this reduction including the sampling effort was less (only 3 sampling events), sampling was conducted over summer (conditions were unfavourable in Spring), and there was a reduced flow in the creek (no riffles were present).

Terrys, Porters and Buffalo Creeks

- Robyn Tuft & Associates (2002) "Macroinvertebrate Sampling Program Lane Cove River Catchments – Autumn 2002". Prepared for Lane Cove River Catchment Councils.
- Robyn Tuft & Associates (2003a) "Macroinvertebrate Sampling Program Lane Cove River Catchments – Autumn 2003". Prepared for Lane Cove River Catchment Councils.
- Robyn Tuft & Associates (2003b) "Macroinvertebrate Sampling Program Lane Cove River Catchments – Spring 2003". Prepared for Lane Cove River Catchment Councils.
- Robyn Tuft & Associates (2004) "Macroinvertebrate Sampling Program Lane Cove River Catchments – Autumn 2004". Prepared for Lane Cove River Catchment Councils.

These programs were aimed at providing information on stream ecology, habitat, and hydrological impacts as well as providing an integrated index of water quality for key stream sites in the catchment area of Lane Cove. Single sampling events were conducted twice yearly from Autumn 2002 to Autumn 2004, using the NSW AusRivAS methodology. Results were assessed using AusRivAS models, SIGNAL2 Indices and the Riparian Channel-Environmental Inventory (RCE) field observations. The three sites of interest (Porters Ck, Terrys Ck, and Buffalo Ck) were reported as being moderate to poor ecological health with impacts from stormwater runoff and scouring flows during high storm events.

2 STUDY AREA

2.1 Site Locations

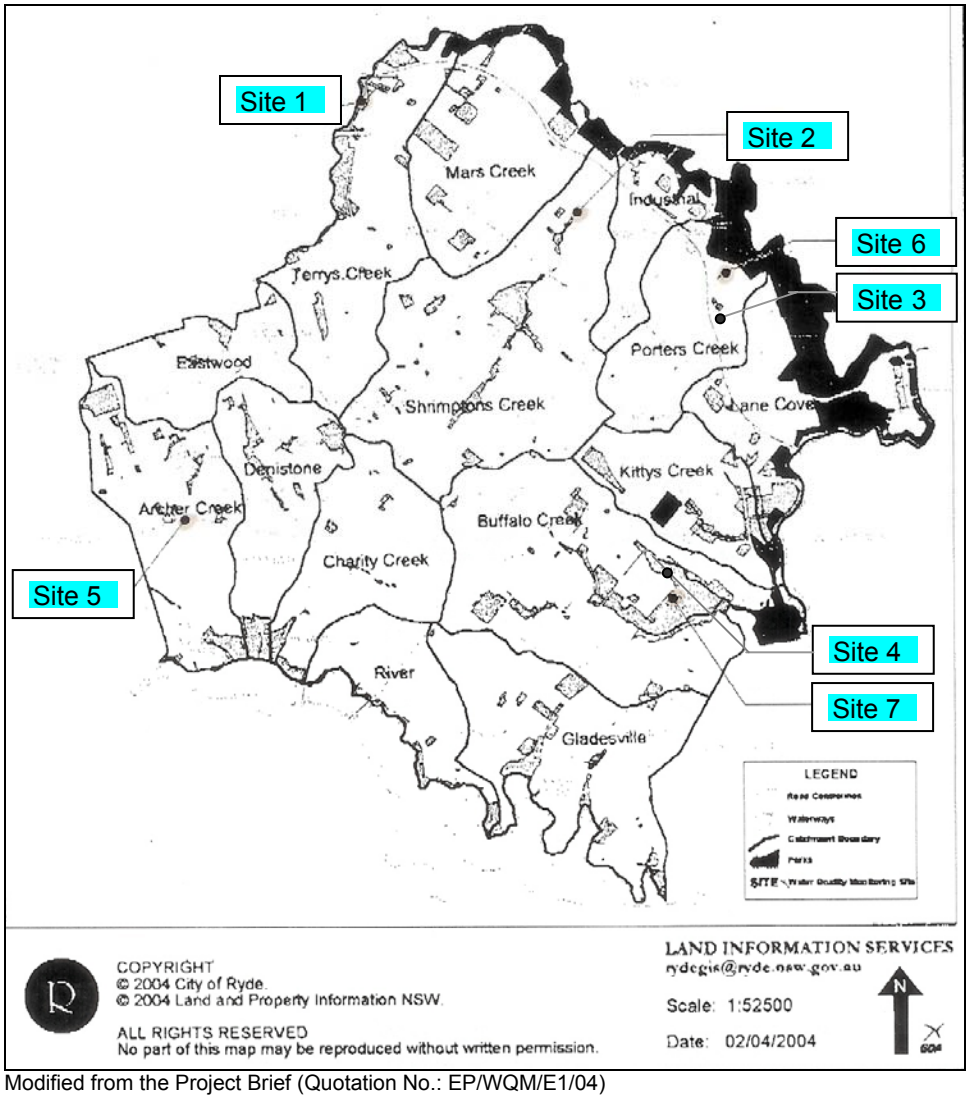
Core sample sites were pre-selected by City of Ryde, and include the following:

- Site 1 – Terrys Ck near the M2 motorway at the end of Somerset Rd, North Epping,
- Site 6 - Porters Ck, accessed through the Ryde Council Depot, *after* the creek is piped under the Depot, and
- Site 7 - Buffalo Ck, accessed through private property (52 Higginbotham Rd).
- Site 2 – Shrimptons Ck at Wilga Park,
- Site 5 – Archer Ck at Maze Park.

The additional two sites (sampled during Spring 2004) included:

- Site 3 – Porters Ck just *before* the stream becomes piped under the Ryde Council Depot,
- Site 4 – Buffalo Ck at Robinson Rd (previously referred to as Higginbotham Rd in Ecowise 2004 report), and

The locality of water quality monitoring sites, within their respective stormwater catchment areas, is presented in Figure 1 (City of Ryde Quotation No: EP/WQM/E1/04).



Modified from the Project Brief (Quotation No.: EP/WQM/E1/04)

Figure 1: Site locations for the Macroinvertebrate and Water Quality Monitoring Strategy for the City of Ryde, Autumn 2005.

2.2 Autumn 2005 Sampling Events

A total of three sampling events were conducted during the Autumn 2005 monitoring program, with all sampling events in separate months as required by the City of Ryde project brief (Quotation No: EP/WQM/E1/04):

- Event 1 – 30th and 31st March,
- Event 2 – 26th and 27th April, and
- Event 3 – 26th and 27th May.

3 METHODS

3.1 Physical Habitat Description

Physical and in-stream habitat descriptions were conducted in accordance with the River Bioassessment Manual and NSW AusRivAS protocols (MRHI, 1994; Turak *et al.*, 2004). Descriptions include using visual estimates of streambed composition (percentage of total for each substrate category), amount of in-stream organic material, and area of aquatic habitats. The mode width, mean depth and channel widths were also determined.

3.2 Water Quality Assessment

At each site, *in situ* dissolved oxygen, pH, electrical conductivity, and water temperature were measured using a Hydrolab DS4 multi-parameter water quality meter coupled to a Surveyor 4 digital display. This meter was fully calibrated in the laboratory in accordance with Ecowise Quality System requirements prior to deployment in the field. Turbidity was measured using a Hach 2100P Turbidimeter.

Water samples were collected for the chemical analyses of Total Dissolved Solids, Total Phosphorus, Total Alkalinity, and Faecal Coliforms, as specified by the City of Ryde project brief. Additional water samples were also collected during the Autumn 2005 sampling event for Total Nitrogen, Total Oxidised Nitrogen and Ammonium.

Water quality data was evaluated using default trigger values for Aquatic Ecosystems of south-east Australian lowland rivers, and the Recreational Waters and Aesthetics for Primary and Secondary Uses as outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) (Table 1).

Table 1: Parameters and relevant water quality guidelines and criteria (ANZECC and ARMCANZ, 2000).

Indicator	Units	ANZECC and ARMCANZ Guidelines (2000)		
		Aquatic Ecosystems	Recreational Waters	
			Primary Contact	Secondary Contact
Conductivity	µS/cm	125 - 2,200	*N/G*	*N/G*
pH	pH units	6.5 - 8.0	5.0 – 9.0	*N/G*
Dissolved Oxygen	% sat	85 - 110	*N/G*	*N/G*
Turbidity	NTU	6 - 50	*N/G*	*N/G*
Total Phosphorus	µg/L	50	*N/G*	*N/G*
Total Nitrogen	µg/L	500	*N/G*	*N/G*
NOx	µg/L	40	*N/G*	*N/G*
Ammonium	µg/L	20	*N/G*	*N/G*
Water Temperature	°C	*N/G*	15 - 35	*N/G*
Faecal Coliforms	orgs/100ml	*N/G*	150	1000

N/G – No guideline

3.3 Macroinvertebrate Sampling

Sampling was undertaken by Ecowise in strict accordance with the protocols defined in the 'NSW Australian River Assessment System (AusRivAS) Sampling and Processing Manual, NSW EPA, July 2004' (Turak *et al.,* 2004). All procedures were diligently followed.

One 10 metre sample was collected from each of the edge and riffle habitats (where these existed) at each site. All sampling was undertaken with ISO DIS/7828 250 μm mesh nets (ISO, 1983). Nets were washed thoroughly in creek water between sampling events to remove any invertebrates retained on them.

Habitats that existed during the Autumn 2005 sampling program are presented in Table 2. Riffle habitats were limited due to the lack of flow in the creeks.

Table 2: Macroinvertebrate habitats sampled during the Autumn 2005 sampling program

Site	Habitats present	
	Edge	Riffle
1	All events	N/P
2	All events	N/P
3	All events	N/P
4	All events	N/P
5	All events	N/P
6	All events	N/P
7	All events	March event only

N/P – not present

3.3.1 Edge Sampling

At each site, the littoral or edge habitat (area along creek bank with little or no current) was sampled by sweeping the sample net along the edge of the stream. The net was swept around overhanging vegetation, against snags if present, in backwaters, and through beds of macrophytes. This process was continued, working upstream, over approximately 10 metres of edge.

3.3.2 Riffle Sampling

The collection of the riffle habitat (fast shallow water over rocky substrate) sample involves placing the sample net immediately downstream of the sample area. The sampler then moves upstream whilst disturbing the substrate, making sure to dislodge stones and other debris. Animals dislodged by this process are carried by the current into the net. Smaller stones are turned and rubbed by hand to dislodge attached macroinvertebrates into the net. Sampling continues until a total distance of 10m has been covered.

3.3.3 Previous Sampling Program Methods

The sampling methods employed by previous sampling programs outlined in Section 1.3 have several differences when compared to the standard NSW AusRivAS protocols (Turak and Waddell, 2001; Turak *et al.,* 2004) employed by Ecowise.

Programs managed by Robyn Tuft and Associates state that samples were collected at each site for a period of 10 minutes and the complete sample was assessed at each site (Robyn Tuft and Ass, 2002; 2003a; 2003b; 2004). In comparison, Turak *et al.,* (2004) require a total length of 10 metres to be sampled of each habitat and the use of a live-picking method on each sample to capture the widest diversity of taxa. Robyn Tuft and Associates (2002; 2003a; 2003b; 2004) did not reference the AusRivAS manual (Turak *et al.,* 2004).

Programs managed by BioTrack reference the AusRivAS manual (Turak *et al.,* 2004) as the methods employed (BioTrack, 2001; 2002; 2004).

3.3.4 Sample Processing

For each sample, the collected material was placed into a sorting tray and macroinvertebrates picked for a minimum of 40 minutes by professionally qualified and experienced aquatic biologists using forceps and pipettes. If new taxa were collected between 30 and 40 minutes, sorting continued for a further 10 minutes. If no new taxa (not previously detected in sample) were found after the 10 minutes, then processing ceased. If new taxa were found, the 10-minute processing cycles were continued up to a maximum total sorting time of 1 hour. There is no set minimum or maximum number of animals collected using the NSW protocols (Turak *et al.,* 2004)

Samples were preserved in 80% ethanol and clearly labelled with information including site, habitat, sampling method, date and sampler. Samples were returned to the laboratory for identification using a dissecting microscope.

Most macroinvertebrate identification was to family level with some exceptions. Chironomidae (Diptera), were identified to sub-family, (Orthocladiinae, Tanypodinae, Chironominae etc.), Collembola, Nematoda and Oligochaeta were identified to class or order level in accordance with accepted convention (MRHI, 1994; Turak *et al.,* 2004) as were the microcrustacea, Ostracoda, Copepoda and Cladocera.

Samples were then preserved in an ethanol/water/glycerol mix for long term archiving and for future morphospecies identification if required.

3.3.5 Data Analysis

After the identification and enumeration of the macroinvertebrates samples, the data was analysed using a number of univariate and multivariate techniques. Both types of techniques provide differing levels of information, with univariate indices concentrating mainly on assessing the condition or “health” of the sites, whilst multivariate analyses allows comparisons between the sites based upon

the community structure to determine if relationships exist between relevant environmental variables and macroinvertebrate communities.

Rapid bioassessment sampling (such as the NSW AusRivAS methods) does not provide a quantitative estimate of the abundance of each taxon in a sample and all macroinvertebrate data was converted to binary form (ie. presence/absence data) prior to analysis.

Univariate Analyses

Richness

Richness refers to the number of different taxa contained in the sample. Unlike some biological indices, a higher number does not always indicate better in-stream conditions. Higher values of this value may indicate favourable conditions in terms of availability of food and/or the quality of habitat. However, in some cases, high richness values can also occur when altered conditions provide habitats that may not occur naturally (e.g. riffle habitats due to altered flow conditions). Each richness value must be assessed individually with a final assessment based upon changes from natural or reference/control condition.

AusRivAS

AusRivAS (Australian River Assessment System) is a prediction system that uses macroinvertebrates to assess the biological health of Australian rivers. AusRivAS uses site-specific predictions of the macroinvertebrate fauna expected to be present in the absence of environmental stress. The expected fauna from sites with similar sets of predictor variables such as physical and chemical characteristics which can not be influenced due to human activities (e.g. altitude), are then compared to the observed fauna. The ratio derived from this comparison is used to indicate the extent of any impact.

Several AusRivAS models currently exist for NSW, including:

- Single-Season models:
  - Spring Edge and Spring Riffle,
  - Autumn Edge and Autumn Riffle, and
- Combined-Season models:
  - Eastern Edge and Western Edge,
  - Riffle.

The Combined-Seasons model involves combining the biological results from Autumn and Spring sampling events for an overall health assessment of sites. However, using a Combined-Seasons model does not allow changes in condition to be detected between season sampling events. As the City of Ryde strategy aims to evaluate chemical and biological water quality monitoring both for short and long term interpretation of creek health, it was not deemed appropriate to use a Combined-Seasons model for the City of Ryde program at this stage.

To run the models, a number of variables are required from each site, depending upon the habitats present. The variables necessary to run the NSW Autumn Edge and Riffle models are presented in Table 3 below.

Table 3: Variables required from each site to run the NSW Autumn Edge and Riffle AusRivAS models.

Edge Habitat	Riffle Habitat	Description
ALKALINITY		Total Carbonates (mg/L)
ALTITUDE	ALTITUDE	Height above sea level (m)
BEDROCK		Percent bedrock in habitat (%)
BOULDER		Percent boulder in habitat (%)
COBBLE		Percent cobble in habitat (%)
LATITUDE	LATITUDE	Latitude of site (decimal degrees to 4dp)
LOGDFSM	LOGDFSM	Log 10 (x) Distance from source
LOGMODEWIDTH		Log 10 (x) average of Mode stream width at site
LOGSLOPE1KUS	LOGSLOPE1KUS	Log 10 (x) Slope: Elevation difference in metres between the middle of the site and a point 1km upstream.
LONGITUDE	LONGITUDE	Longitude of site (decimal degrees to 4dp)
RAINFALL	RAINFALL	Mean annual rainfall (mm)

Observed / Expected Ratios

The Observed / Expected (OE) ratio can range from zero, when none of the expected taxa are found at a site, to around one, when all the expected taxa are present. The value can also be greater than one when more families are found at the site than expected by the model. The OE scores derived from the model can be placed in bands delineated by the Monitoring River Health Initiative (Table 4), which allows assessment of the level of environmental health at a site.

Table 4: Key to AusRivAS OE family scores and bands for NSW Autumn Edge and Riffle habitats.

Band Label	OE50 scores		Band Name	Comments
	Edge	Riffle		
Band X	Infinity	Infinity	More biologically diverse than reference sites.	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	1.17	1.13	Reference condition.	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	0.81	0.86	Significantly impaired.	Fewer families than expected. Potential impact either on water quality or habitat quality or both resulting in loss of taxa.
Band C	0.46	0.60	Severely impaired.	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	0.11	0.34	Extremely impaired.	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

Taxa Probability

The AusRivAS output also allows the ability to identify any *'indicator taxa'* collected or missing from the sample by measuring a taxa's probability of occurrence. The AusRivAS output includes:

- Taxa expected to be in the sample, that ***is*** collected; and
- Taxa expected to be in the sample, that is ***not*** collected.

Any taxa with a greater than 50% probability of occurrence, as indicated by the AusRivAS model, is expected to be collected if the site is in a healthy reference condition.

Indicator taxa are defined in this report as taxa within the PET (Plecoptera - stoneflies, Ephemeroptera - mayflies, and Trichoptera - caddisflies) orders, and/or with a SIGNAL2 score of equal to or greater than 6, having a moderate to high level of sensitivity to pollution. PET taxa have been found in many biomonitoring programs to be the orders most sensitive to environmental disturbance, and usually taxa belonging to these orders are the first to disappear following disturbance (EHMP, 2004).

This information, along with the taxa's SIGNAL2 score, will allow an assessment to be made of potential 'indicator taxa' present or absent from samples, which may be influencing the assessment of river health.

SIGNAL2

SIGNAL2 (Stream Invertebrate Grade Number Average Level - Version 2) (Chessman, 2003) is a simple scoring system for macroinvertebrates of Australian rivers and is derived from known responses of macroinvertebrate taxa to water pollution. Each taxon is assigned a number from 1 (tolerant) to 10 (sensitive). The site index has been calculated in the past by summing the sensitivity scores for all families present and then dividing by the number of families present (average of scores for all families in a sample).

The interpretation of the more recent SIGNAL2 data follows that suggested by Chessman (2003) and Coysh *et al*. (2000). In order to overcome natural variation, Chessman (2003) suggests using the observed / expected (OE) SIGNAL2 scores predicted using AusRivAS. The observed (O) SIGNAL2 score is the sum of the grades of taxa collected, divided by the number of families collected. The expected (E) SIGNAL2 score is obtained by multiplying the grade of each taxon by its probability of collection, summing the products, and dividing by the sum of the probabilities.

The example below (Table 5) used by Chessman (2003) best explains this equation.

Table 5: Simplified hypothetical example of the suggested use of AusRivAS computer outputs to calculate a predicted SIGNAL2 score (Chessman, 2003)

Taxon	SIGNAL2 grade	Probability of collection	Grade x Probability	Taxon Collected?
Family A	5	1	5	yes
Family B	3	0.8	2.4	no
Family C	10	0.6	6	no
Family D	7	0.6	4.2	yes
Family E	8	0.5	4	yes
Family F	4	0.3	1.2	yes
Family G	7	0.1	0.7	no
Family H	9	0.1	0.9	no
Family I	5	0	0	no
Family J	1	0	0	yes
Sum		**4**	**24.4**	

Observed Score = (5 + 7 + 8 + 4 + 1) / 5 = 5.0
Expected Score = 24.4 / 4.0 = 6.1

O/E50SIGNAL2 = 5.0 / 6.1 = 0.82

Currently, no bandings have been developed for this analysis (Coysh *et al.,* 2000; Chessman *pers comm*); however, an OE50SIGNAL2 score of around 1 would suggest the observed SIGNAL2 score was similar to what was expected at the site.

One-way ANOVA

One-way Analysis of Variance (ANOVA) was used to assess differences in richness, AusRivAS OE scores, and SIGNAL values between the two additional sites and the two core sites collected by Ecowise in Spring 2004 along Buffalo Ck and Porters Ck.

ANOVA is a parametric statistical technique that requires data to be normally distributed and have equal variances. Assumptions of normality and homogeneity of variances was assessed using the Kolmogorov-Smirnov test with Lilliefor's correction. Where necessary, data was transformed in an effort to satisfy the normality and variance criteria. Where this could not be achieved, a Kruskal-Wallis One Way Analysis of Variance on ranks was conducted. This is a non-parametric technique that has far less stringent requirements for normally distributed, equal variance data.

Due to the small dataset for the site comparisons assessment in this report, normality could not be achieved therefore the non-parametric technique was used for all analyses.

ANOSIM

Analysis of Similarities (ANOSIM) was used to compare the macroinvertebrate community data between the two additional sites and the two core sites collected by Ecowise in Spring 2004 along Buffalo Ck and Porters Ck.

ANOSIM compares the similarity of samples within groups to the similarity of samples between groups. It should be noted that sample groupings were defined *a priori* and were not based on the findings of classification or ordination analyses. The test uses a randomisation procedure to test the hypothesis that there is no difference in community structure between site/sample groups. Each randomisation compares the R test statistic generated from the randomly sorted data set with the R-value calculated from the original data set. One thousand randomisations of the data were undertaken for each comparison. Although the value of R can vary between -1 and 1, values usually fall between 0 and 1. Values less than 1 indicate the generally unusual situation of lower levels of similarity within treatments or groups than between them (Clarke and Warwick, 2001). R-values approximating 0 indicate that the null hypothesis is true and that there are no differences between the assessed factors. As values increasingly depart from zero (normally towards 1), there is an increasing indication of differences between the groups/factors being assessed. A value of 1 indicates that all replicates within a treatment/group are more similar to each other than to any others from different treatments/groups (or for –1, that all replicates within a treatment/group are more similar to those from different treatments/groups).

Multivariate Analyses

The use of multivariate analysis techniques allow exploration into the patterns of the macroinvertebrate communities of which univariate techniques cannot. The routines used in this study will allow patterns (if any) between sites/samples to be identified (Classification and Ordination), the key taxa from each sample which may be contributing to these differences (SIMPER) and the isolation of environmental variables that could be responsible for observed patterns (BVSTEP).

Community multivariate analyses can be significantly altered due to rare or uncommon taxa occurring. In this study, rare taxa were excluded prior to analysis primarily due to their occurrence being more a matter of chance rather than being properly represented in the community. Rare taxa do not contribute information to the patterns existing within the data, rather they can create 'noise' which has the effect of masking patterns (Clarke and Warwick, 2001). A common cut-off level used in presence/absence data is greater than 5% occurrence in samples (Clarke and Warwick, 2001) and this level was applied for this study. All multivariate analyses were performed using the statistical package PRIMER Version 5.2.9 (PRIMER-E: Plymouth Marine Laboratory, UK).

Classification

Classification (also called *cluster analysis*) is a mathematical method of grouping entities according to the relative similarity of their attributes. In an ecological setting these techniques can be used to group sites according to the similarity of the organisms found within them.

The initial step in this process was to calculate a similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient (Bray & Curtis, 1957; Clifford & Stephenson, 1975). From this matrix, hierarchical agglomerative clustering was obtained. This classification formed the basis for the construction of a dendrogram, which presents the sites as groups based on a pattern of branching points, each defined by a level of similarity.

Ordination

Like classification, ordination provides a representation of the relative similarity of entities (i.e. site samples) based on their attributes (i.e. macroinvertebrate community composition) within a reduced dimensional space. The more similar sites are to each other, the closer they are located within the ordination space. This procedure is useful to display the samples' interrelations on a continuous scale and allows a check to see how "real" the groups identified in the classification technique are.

A Non-metric Multi-Dimensional Scaling (NMDS) ordination was performed on the similarity matrix for all pairs of samples based on the Bray-Curtis similarity coefficient. The number of axes used in the ordinations was based on resultant stress levels. The stress level is a measure of the distortion produced by compressing multi-dimensional data into a reduced set of dimensions and will increase as the number of axes (i.e. dimensions) is reduced. All ordinations were initially calculated for two axes; however, if the resultant stress level exceeded 0.30, the ordination was recalculated for three axes (i.e. 3 dimensions). A stress level of <0.2 is considered a useful ordination.

SIMPER

The SIMPER (SIMilarity PERcentages) routine was used to identify taxa that contributed most to the average dissimilarity between site groups identified from the classification (cluster analysis). SIMPER computes the average dissimilarity (Bray-Curtis) between all pairs of inter-group samples (every sample in group 1 with every sample in group 2 etc.) and then breaks this average down into the separate contributions from each taxon. In addition to calculating the average dissimilarity between groups, SIMPER also calculates the average similarity within a group.

BVSTEP

The proportion of macroinvertebrate variation explained by measured environmental variables (e.g. water depth, substrate composition etc) was calculated using the BVSTEP routine. BVSTEP is a procedure that calculates agreement between the macroinvertebrate similarity matrix (Bray-Curtis) and multiple Euclidean distance matrices derived from environmental variables (Clarke and Gorley, 2001). It is important to quantify the factors that may be contributing to the differences between sites, as it is a means of directly associating the changes related to an environmental factor and eliminates the "guess work" in identifying the possible causes in changing community composition.

4 RESULTS

4.1 Rainfall Data

Daily rainfall data collected from a weather station in Marsfield over the past twelve months is indicated in Figure 2. All events were found to have minimal rainfall in the week preceding sampling (<10mm in 7 days), with two sampling events recording zero rainfall in that period (October 2004 and May 2005).

A high volume of rainfall was recorded between the October sampling event and November sampling event (305.6mm), in comparison to those recorded between other events, including 95.8mm between September and October, 27.2mm between March and April, and 40.8mm between April and May.

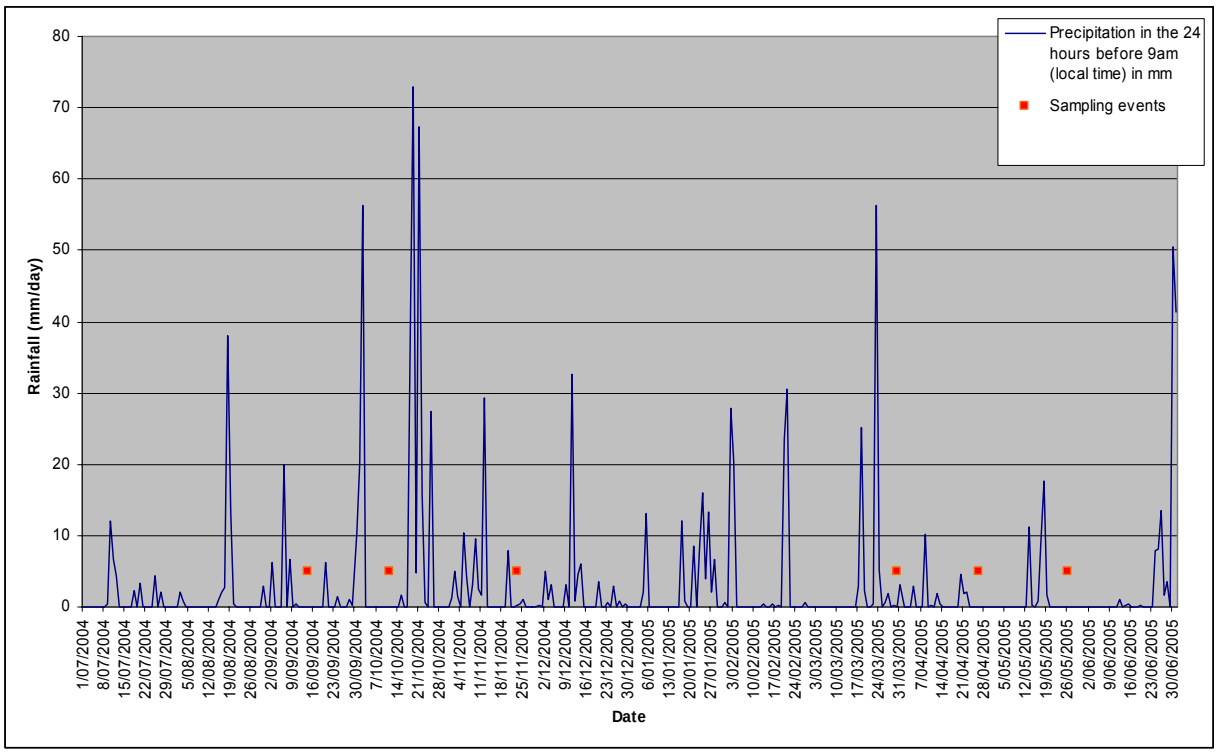


Figure 2: Daily rainfall data (mm) from Marsfield (Bureau Of Meteorology Station #.: 066156) between July 2004 to June 2005. The sampling events during Spring 2004 and Autumn 2005 are also indicated.

4.2 Water Quality

4.2.1 *In situ* results

The results for *in situ* water quality parameters measured at each of the macroinvertebrate sites over the course of the program are presented in Table 6.

Table 6: In situ water quality results from the seven sites within the City of Ryde, Autumn 2005. Results outside the ANZECC and ARMCANZ (2000) guidelines have been highlighted in red.

Site	Sampling Event	Time sampled	Water Temp. (°C)	Conductivity (µS/cm)	pH	DO (mg/L)	DO (%sat.)	Turbidity (NTU)
***Aquatic Ecosystems**			**N/A**	**125 - 2200**	**6.5 – 8.0**	**N/A**	**85 - 110**	**50**
^Primary Contact			**15-35**	**N/A**	**5.0 – 9.0**	**N/A**	**N/A**	**N/A**
1	March	12:00	16.92	315.2	7.22	8.44	86.9	42
	April	13:30	15.83	264.2	6.60	6.60	66.1	1.66
	May	12:15	10.77	324.8	7.25	8.34	74.4	1.80
2	March	10:30	17.07	305.3	6.71	4.46	44.3	9.0
	April	12:40	17.31	236.5	6.44	5.73	60.0	3.21
	May	13:45	11.92	333.1	7.18	5.65	51.2	4.94
3	March	11:30	19.25	1714	7.45	6.47	59.6	51.3
	April	11:00	20.42	2694	7.14	7.74	86.2	0.95
	May	13:30	17.46	2735	7.70	8.82	90.3	1.21
4	March	14:45	18.04	212.6	7.25	8.45	88.2	75.5
	April	11:20	16.60	883.7	6.84	4.88	50.0	3.64
	May	9:30	10.46	1006	7.42	6.75	60.2	2.44
5	March	13:30	19.55	183	7.05	7.49	81.1	22.2
	April	12:40	17.44	260.9	6.84	5.80	60.2	1.45
	May	10:40	10.83	376.1	7.40	8.14	72.6	3.32
6	March	10:00	18.32	1719	7.31	7.61	79.8	18.9
	April	9:40	18.27	2520	7.24	8.77	94.6	3.64
	May	11:45	15.61	2305	7.74	10.02	99.4	1.53
7	March	12:00	17.81	240.9	7.63	8.37	86.9	17.4
	April	15:10	16.58	547.6	6.7	5.4	55.4	7.56
	May	14:45	12.65	641.3	7.54	7.39	68.8	7.14

* - ANZECC and ARMCANZ (2000) guidelines for Aquatic Ecosystems – lowland rivers of south eastern Australia
^ - ANZECC and ARMCANZ (2000) guidelines for Recreational Water Quality and Aesthetics (Primary eg swimming; Secondary eg. Boating).

A review of the water quality data showed that dissolved oxygen concentrations regularly fell below the recommended ANZECC and ARMCANZ guideline value of 85% saturation across all sites for at least one sampling event in Autumn 2005.

Conductivity in Porters Ck (Sites 3 and 6) was recorded above the ANZECC and ARMCANZ (2000) guideline for Aquatic Ecosystems during the April and May sampling events. On both occasions the result was higher upstream at Site 3 than downstream at Site 6.

Water temperature was the other significant result with a drop of at least 4°C at five of the seven sites between April and May sampling events.

4.2.2 Laboratory Water Quality Results

Results for the laboratory analyses of water samples at each of the macroinvertebrate sites over the course of the program are presented in Table 7.

Table 7: Laboratory analysed water quality results from the seven sites within the City of Ryde, Autumn 2005. Results outside ANZECC and ARMCANZ (2000) guidelines have been highlighted in red.

Site	Sampling Event	Time sampled	TDS (mg/L)	TP (µg/L)	TN (µg/L)	NOx (µg/L)	TKN (µg/L)	NH_4^+ (µg/L)	Faecal Coliforms (orgs/100ml)	Total Alk. ($CaCO_3$)
*Aquatic Ecosystems			N/A	50	500	40	N/A	20	N/A	N/A
^Primary Contact			N/A	N/A	N/A	N/A	N/A	N/A	150	N/A
^Secondary Contact			N/A	N/A	N/A	N/A	N/A	N/A	1000	N/A
1	March	15:10	130	100	970	170	800	590	60000	40
	April	10:30	180	40	440	140	300	70	90	62
	May	10:15	180	30	370	110	260	40	130	61
2	March	9:20	170	40	520	240	280	20	3400	52
	April	10:15	160	30	370	100	270	40	940	65
	May	10:40	180	30	560	290		40	400	65
3	March	11:30	700	430	--	--	--	--	28000	97
	April	10:05	1900	10	1600	460	1100	310	50	25
	May	9:15	1600	10	1500	470	1000	190	30	17
4	March	14:30	140	150	760	230	530	220	10	58
	April	11:30	580	40	430	110	320	70	160	109
	May	9:30	620	20	490	240	250	40	46	99
5	March	14:50	180	60	400	50	350	20	360	68
	April	12:40	160	10	260	20	240	40	300	78
	May	10:00	200	20	380	70	310	60	360	99
6	March	10:30	1100	40	1900	820	1100	670	1000	99
	April	10:00	1800	20	1700	590	1100	400	220	35
	May	9:00	1500	20	1700	640	1100	350	59	30
7	March	12:45	140	30	660	290	370	130	36	59
	April	11:00	390	40	--	--	--	--	520	95
	May	9:40	360	40	650	350	300	90	170	92

* : ANZECC and ARMCANZ (2000) guidelines for Aquatic Ecosystems – lowland rivers of south eastern Australia
^ : ANZECC and ARMCANZ (2000) guidelines for Recreational Water Quality and Aesthetics (Primary eg swimming; Secondary eg. Boating).
-- : laboratory handling error, sample not analysed.

High nutrient levels of Nitrogen and Ammonium were recorded in all creeks during the Autumn 2005 sampling program, with Porters Ck recording the highest results. Site 3 recorded over 15 times the recommended trigger level set by ANZECC and ARMCANZ (2000) for Ammonium, and over ten times the trigger level for Total Nitrogen, during the April sampling program. Site 6 (downstream of Site 3) consistently recorded nutrient results higher than Site 3. Conversely, Site 5 recorded the lowest nutrient results for Nitrogen and Ammonium over the course of the program, with four out of nine results within the guidelines and the remaining 5 results only marginally above the guidelines.

Total Phosphorus levels above the guidelines were recorded for 5 sites during the March event, with Site 3 recording over eight times the guideline level. Site 6 (downstream of Site 3) Total Phosphorus results were below the guideline level during the same sampling event All sites recorded results below the guidelines for Total Phosphorus during the April and May sampling events.

Faecal coliform results were above the primary contact guideline at all sites during at least one sampling event in Autumn 2005. Also, four of the seven sites during the March program were above the secondary contact results, with Site 1 recording a level 60 times the guideline limit. Faecal coliform results were below the secondary contact level during the April and May events.

4.3 Macroinvertebrate Results

4.3.1 General Characteristics of Aquatic Macroinvertebrates

A total of 47 different families were recorded over the three Autumn sampling events, with insects the most dominant (26 taxa) followed by gastropods (4 taxa), and crustaceans (3 taxa). A full macroinvertebrate taxa list is presented in **Appendix A**.

4.3.2 Univariate Analyses

Macroinvertebrate Taxa Richness

Taxa richness for each of the macroinvertebrate sites over the three events is presented in Table 8.

Table 8: Macroinvertebrate taxa richness from seven sites within the City of Ryde, Autumn 2005.

Site	Habitat	Sampling Event			Combined sample diversity
		March	April	May	
1	Edge	20	19	22	29
2	Edge	11	11	10	16
3	Edge	14	13	13	18
4	Edge	14	17	16	25
5	Edge	18	18	16	22
6	Edge	21	18	17	25
7	Edge	22	23	23	32
	Riffle	16	N/P	N/P	16

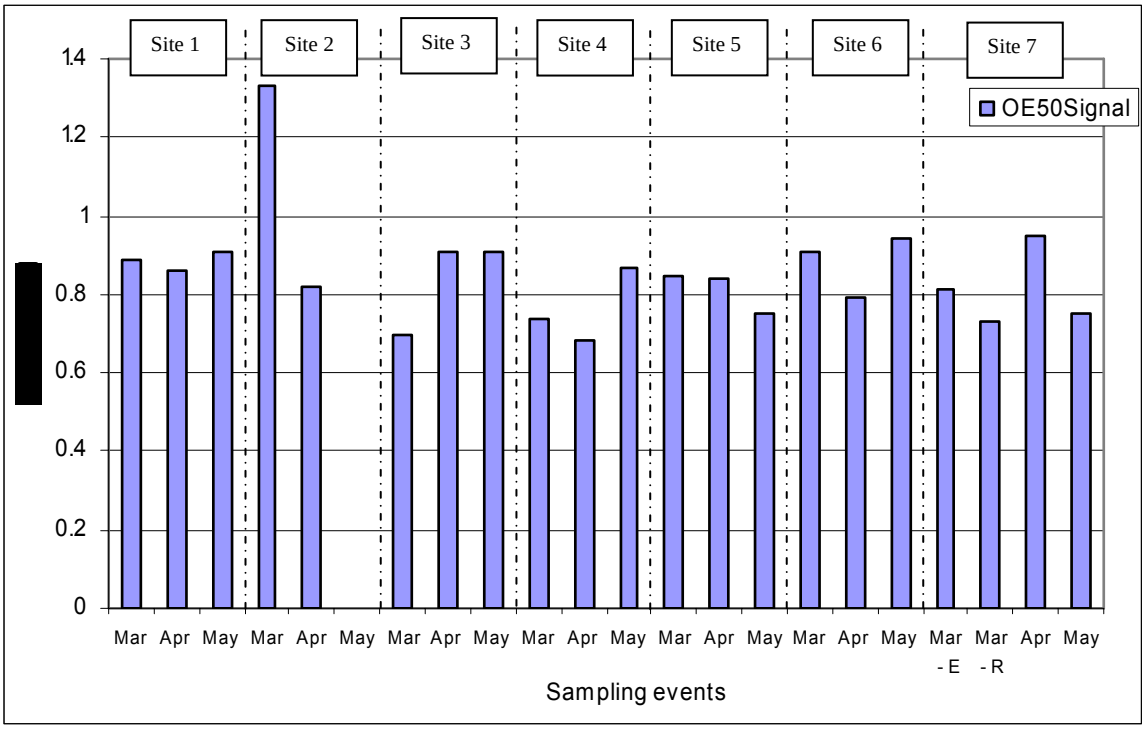
N/P – not present

Taxa richness was highest in the edge habitat at Site 7 during each sampling event, and had the highest combined sample diversity for the Autumn 2005 program. The lowest taxa richness was recorded in the edge habitat at Site 2 during each event and also resulted in the lowest combined sample diversity for Autumn 2005.

SIGNAL2

SIGNAL2 scores for each of the seven sites over the three events are presented in Figure 3.

Most O/E50Signal results were between 0.8 and 1.0. The riffle sample collected at Site 7 during March resulted in an O/E50Signal Score of below 0.8. While Site 2 recorded a taxa diversity of 10 or 11 throughout the program (Table 8), the site recorded a decreasing trend of the highest O/E50Signal score during March to the lowest O/E50Signal score during May.



Note: E – Edge; R - Riffle

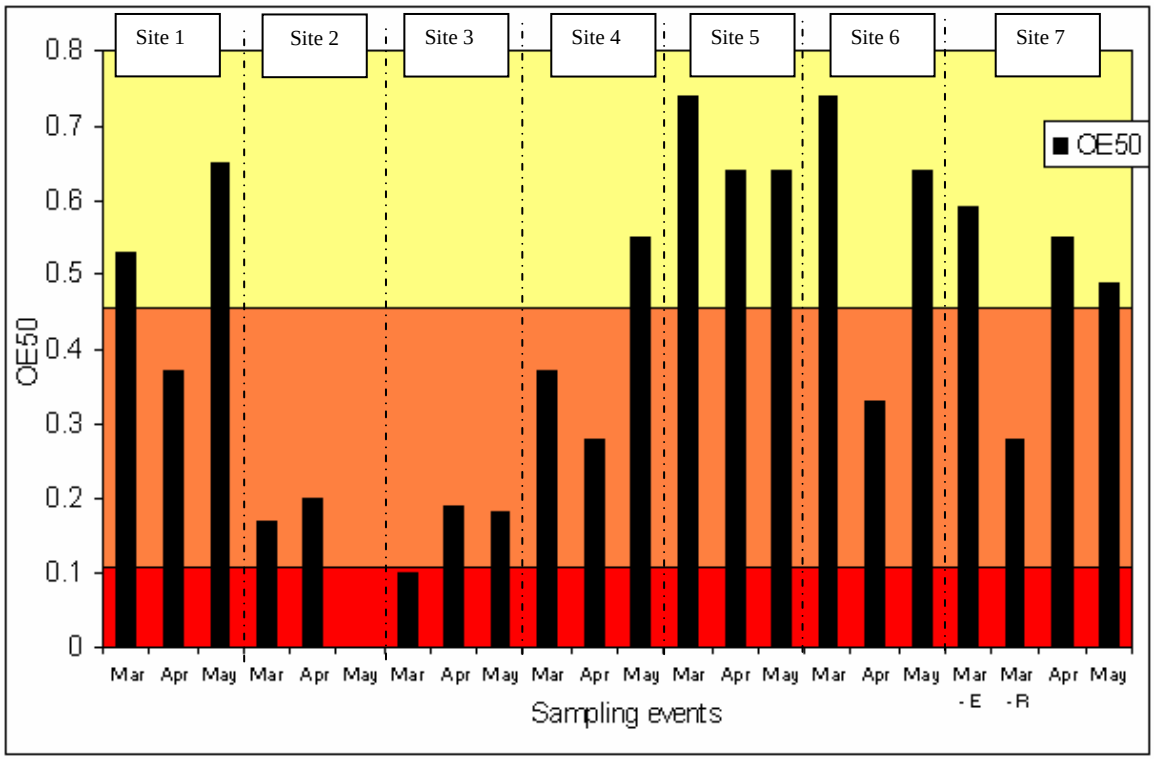
Figure 3: O/E50SIGNAL scores from the seven sites within the City of Ryde, Autumn 2005.

AusRivAS

Observed / Expected Ratios

AusRivAS results for each of the core sites over the three events are presented in Figure 4.

The majority of AusRivAS results were recorded in Band B, with 11 out of 21 results above 0.46, followed by 9 results in Band C (including the riffle result), and 2 results in Band D. Two sites recorded all sampling events in Band B, including Sites 5 and 7 (not including riffle), while Sites 2 and 3 recorded the lowest O/E scores, two samples in Band C and one in Band D.



Note: E – Edge; R - Riffle

Figure 4: AusRivAS results from the seven sites within the City of Ryde,Autumn 2005. The AusRivAS bandings are also presented; D – Red, C – Orange, B – Yellow.

Taxa Probabilities

The AusRivAS taxa probability results for the Autumn 2005 program are presented in **Appendices B** and **C**. A total of 20 expected taxa were missing from samples collected over the Autumn 2005 sampling event, with 3 of those missing within the PET taxa orders.

The PET taxa which had a >50% expectation at each site included:

- Leptophlebiidae (8) – Ephemeroptera (mayflies);
- Leptoceridae (8) - Trichoptera (caddisflies); and
- Baetidae (5) - Ephemeroptera (mayflies).

Leptophlebiidae (8) was not collected in any of the samples yet was considered to have an 82-100% probability of occurrence in all samples. In contrast, Baetidae (5) was collected in one sample in Site 6 yet was only expected at 53% in one sample at Site 1. Leptoceridae (8) was expected (>86%) in all samples across all sampling events yet was only collected in 2 samples at Site 6 (March and May).

Other indicator taxa expected in the samples included:

- Acarina (6) – mites
- Scirtidae (6) – beetles.

While a number of samples collected Acarina and Scirtidae (10 out of 21 samples observed Acarina, and 3 out of 21 samples observed Scirtidae) both taxa were >50% expected in all samples.

The remaining 15 taxa >50% expected but not observed in the samples were all considered to be pollution tolerant taxa.

The taxa collected during all three events during Autumn 2005 at each site, and dominating the samples, are presented in Table 9. The dominant taxa across all sites was Oligochaeta (2) (worms) and Physidae (1) (snails), both taxa tolerant of pollution. Other taxa dominating most sites included Chironominae (3) (biting midges), Planorbidae (2) (snails), and Megapodagrionidae (5) (damselfly).

Table 9: Taxa collected in all samples during all three events at each site, Autumn 2005 City of Ryde.

Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site7
Chironominae	Corbiculidae	Chironominae	Chironominae	Chironominae	Chironominae	Chironominae
Oligocheata	Oligocheata	Oligocheata	Oligocheata	Oligocheata	Oligocheata	Oligocheata
Physidae	Physidae	Physidae	Physidae	Physidae	Physidae	Physidae
Tanypodinae	Dugesidae	Ancylidae	Hydrobiidae	Tanypodinae	Tanypodinae	Tanypodinae
Corbiculidae	Planorbidae	Hydrobiidae	Planorbidae	Coenagrionidae	Hydrobiidae	Coenagrionidae
Dugesidae	Glossiphoniidae	Planorbidae	Glossiphoniidae	Hemicordulidae	Planorbidae	Hemicordulidae
Hydrobiidae		Erpobdellidae	Coenagrionidae	Megapodagrionidae	Glossiphoniidae	Megapodagrionidae
Planorbidae		Isostictidae	Hemicordulidae	Dugesidae	Aeshnidae	Dugesidae
Notonectidae		Megapodagrionidae	Megapodagrionidae	Libellulidae	Coenagrionidae	Glossiphonidae
Glossiphoniidae			Notonectidae	Veliidae	Hemicordulidae	Notonectidae
Hemicordulidae				Stratiomyidae	Megapodagrionidae	Planorbidae
Isostictidae				Atyidae	Libellulidae	Hydrobiidae
Megapodagrionidae					Isostictidae	Stratiomyidae
						Corbiculidae
						Acarina

Taxa Comparison with Spring 2004

A comparison of macroinvertebrate taxa observed in samples from Sites 1 to 5 in Spring 2004 and Autumn 2005 are presented in Table 10.

The most dominant taxa present in all samples across both sampling programs were Oligochaeta (worms) and Physidae (snails), with Chironominae (biting midges) present in all but two samples from Site 2 in Autumn.

Other very common taxa present in most samples from both programs included:

- Coenagrionidae (2) and Megapodagrionidae (5) – Odonata: damselflies,
- Hemicordulidae (5) – Odonata: dragonflies,
- Corbiculidae/Sphaeriidae (4/5) – Bivalvia: freshwater muscles,
- Dugesidae (2) – Turbellaria: flatworms,
- Hydrobiidae (4) and Planorbidae (2) – Gastropoda: snails, and
- Stratiomyidae (4) – Diptera: soldier flies

Table 10: Comparison of macroinvertebrate taxa observed in City of Ryde samples for Sites 1 to 5 in Spring 2004 and Autumn 2005 (■ taxa present in three samples, ● taxa present in two samples, ▼ taxa present in one sample). Signal grades for each taxa are presented in brackets.

Taxa	Site 1		Site 2		Site 3		Site 4		Site 5	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
Acarina (6)		●	●	▼			▼	▼	■	●
Aeshnidae (4)		▼					▼	●	●	●
Ancylidae (4)	▼		■			■				
Atyidae (3)	▼								▼	■
Baetidae (5)									▼	
Belostomatidae (1)	▼									
Ceinidae (2)		●						●		
Ceratopogonidae (4)		▼	▼							
Chironominae (3)	■	■	■	▼	■	■	■	■	■	■
Cladocera								▼		
Coenagrionidae (2)	■	●	●	●		●	●	■	■	■
Copepoda	●	▼	■	●	▼	●			●	●
Corbiculidae/ Sphaeriidae (4/5)	■	■	■	■		●	▼	●	●	▼
Corixidae (2)			●							●
Culicidae (1)						▼		▼		
Dugesiidae (2)	■	■	■	■		▼		●	■	■
Dytiscidae (2)									▼	●
Elmidae (7)	●	●								
Erpobdellidae (1)				▼		■		▼		
Gelastocoridae (5)		▼		▼						
Gerridae (4)	▼	▼								
Glossiphoniidae (1)		■		■		▼	●		●	
Gomphidae (5)	▼	■	▼	■		▼		■		▼
Hemicorduliidae (5)	■	■	■	▼		●	■	■	■	■
Hydrobiidae (4)	■	■	▼		●	■	■	■	■	
Hydroptilidae (4)	▼		●						●	
Isostictidae (3)	▼	■				■				
Leptoceridae (6)			▼						▼	
Lestidae (1)			▼						▼	
Libellulidae (4)			▼			▼		▼	■	■
Lymnaeidae (1)	▼									
Megapodagrionidae (5)	■	■	▼		■	■	■	■	▼	■
Naucoridae (2)	▼	▼								
Nematoda (3)			▼			▼			●	
Notonectidae (1)	▼	■					■	■	▼	▼
Oligochaeta (2)	■	■	■	■	■	■	■	■	■	■
Oniscidae (2)					▼			▼		
Orthocladiinae (4)	●	●		▼			▼	▼	●	▼
Ostracoda	▼	▼	■	●			▼	▼	■	●
Physidae (1)	■	■	■	■	■	■	■	■	■	■
Planorbidae (2)	●	■	■	■	■	■	■	■		
Psychodidae (3)					▼					
Scirtidae (6)	▼	▼								
Simuliidae (4)								▼		
Stratiomyidae (4)	▼	●	▼	●			●	▼	●	■
Tanypodinae (4)	●	■					▼	▼	■	■
Telephlebiidae (5)							●			
Tipulidae (4)		▼							●	
Veliidae (1)		▼					●		●	■

Most taxa observed during a single season program only, were only present in <20% of samples collected for that season, suggesting those taxa to be rare. A total of 14 taxa from the 49 taxa observed were isolated to one program only, and only three of those taxa were collected in more than two samples. They were:

- Erpobdellidae (1) (leech) – 5 samples, isolated to Autumn 2005 only,
- Ceinidae (2) (isopod) – 4 samples, isolated to Autumn 2005 only, and
- Hydroptilidae (4) (cased caddisfly) - 5 samples, isolated to Spring 2004 only.

A total of 8 taxa were isolated to the Spring program only, with 3 of the 8 taxa present classified as indicator taxa (2 x Trichoptera and 1 x Ephemeroptera). There were 6 taxa isolated to the Autumn program only, with no animals classified as indicator taxa.

4.3.3 Multivariate Analyses

Only one riffle habitat sample was collected during the Autumn 2005 program from Site 7. This sample was removed from the multivariate analyses as it is a different habitat with different macroinvertebrate composition. Also, being a single sample only, the riffle sample has no comparative data collected during Autumn 2005.

Classification and Ordination

Classification of the edge habitat samples over the three events revealed 4 out of the 7 sites had a 75% or greater similarity in macroinvertebrate community composition, including Sites 1, 4, 6 and 7 (Figure 5).

Site 2 samples were revealed to be the most dissimilar to the other samples based on macroinvertebrate community composition, by separating from the remaining samples at the 55% similarity. Site 3 samples were the second group to separate at the 59% similarity, followed by the third grouping of samples from Site 5 (65% similarity level). The remaining samples did not separate out until the 75% and greater similarity level.

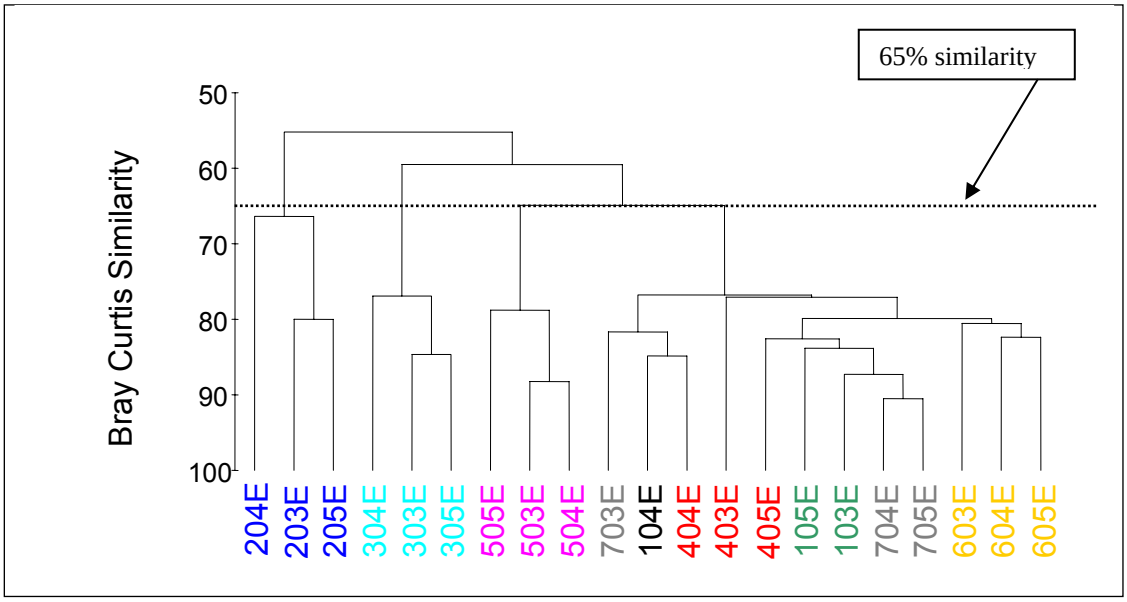


Figure 5: Classification of macroinvertebrate samples collected from seven sites during the Autumn 2005 monitoring program, City of Ryde. Samples labelled with site code (eg. 1 – Terrys Ck), sampling month (eg. 03 - March) and habitat (E – edge). 65% similarity is indicated.

The groupings presented in Figure 5 are further enhanced in the NMDS plot (Figure 6) at the 65% similarity level.

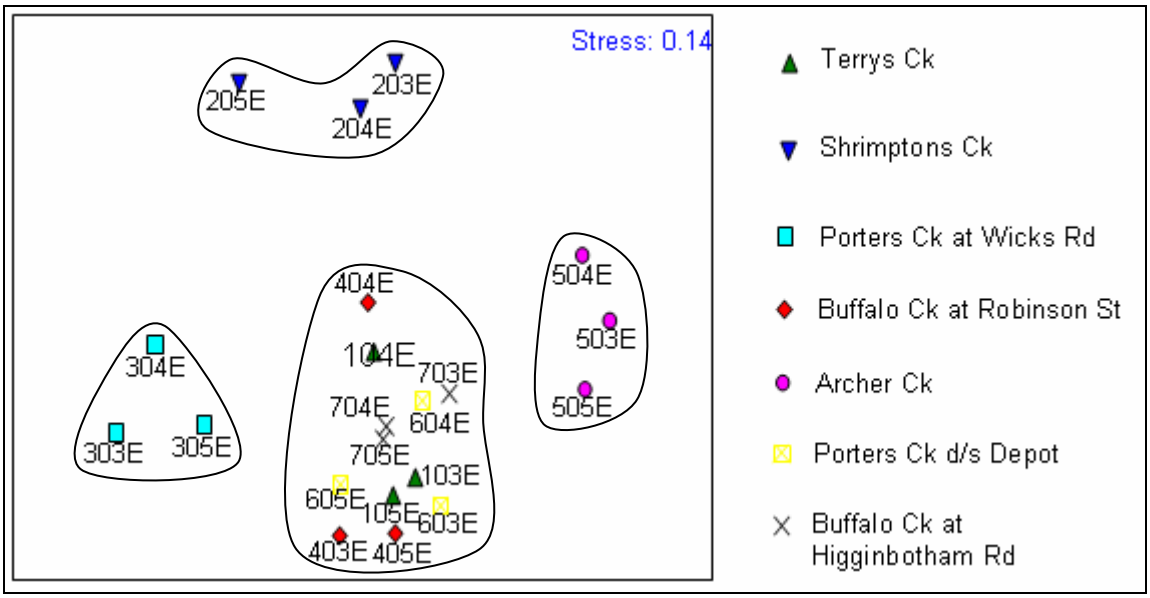


Figure 6: Non-metric Multi-dimensional Scaling (NMDS) ordination of macroinvertebrate samples collected from seven sites during the Autumn 2005 monitoring program, City of Ryde. Superimposed groupings refer to the 65% similarity level from the classification. (stress was calculated at 2 dimensions).

SIMPER

The SIMPER average dissimilarity results based on community composition between the seven sites is presented in Table 11. The raw data is presented in **Appendix E.**

Table 11: Average dissimilarity (%) results for community composition data from samples collected at seven sites during the Autumn 2005 monitoring program, City of Ryde.

Site	1	2	3	4	5	6	7
1							
2	40.35						
3	37.54	47.56					
4	23.32	42.09	37.28				
5	36.47	49.20	54.30	40.39			
6	20.90	48.48	34.74	25.18	32.82		
7	16.52	41.22	38.77	20.88	30.84	19.31	

The highest dissimilarity was recorded between Sites 3 and 5 (54.30%). Both sites contained taxa only present in one of the two sites. Site 3 recorded Hydrobiidae (snails), Isostictidae (damselflies), Planorbidae (snails), Ancylidae (limpets) and Erpobdellidae (leeches) in all three samples during Autumn while there were not collected in any samples at Site 5. Conversely, Site 5 recorded Stratiomyidae (soldier flies), Tanypodinae (biting midges), Veliidae (water strider), and Atyidae (shrimp) in all samples which were not collected in any samples from Site 3.

The lowest dissimilarity (most similar) result was recorded between Sites 1 and 7 (16.52%). Neither Site 1 nor Site 7 contained taxa which was present in *all* three samples from one site and not the other. Of the fourteen bugs contributing to the similarity, only four taxa were collected in one or two samples from one site only. The presence of two indicator taxa (Acarina and Scirtidae) in some samples at both sites also contributed to the similarity.

BVSTEP

The output from the BVSTEP routine on the results from the seven sites is presented in **Appendix F**.

BVSTEP found 8 environmental variables to attribute a 20% (0.449 correlation) difference between samples. The variables included:

- Water temperature
- pH
- Pebble substrate composition (%)
- Gravel substrate composition (%)
- Sand substrate composition (%)
- Silt/Clay substrate composition (%)
- Presence of branches in sample area (%)
- Presence of macrophytes in sample area (%)

This result suggests that habitat characteristics, mainly substrate composition not water quality, are causing the difference in community composition; however the correlation is not strong.

Additional Site Comparisons

Further investigations were conducted to assess similarities between the samples collected in Porters and Buffalo Cks from sites visited during the Spring 2004 program and historical site locations along the same creeks. Samples were collected from both sites during each sampling event conducted in Autumn 2005 to allow a direct comparison.

Porters Ck

The two sites along Porters Ck are Site 3, accessed at Wicks Rd, and Site 6, located approximately 1km downstream of Site 3 and accessed through the Council Depot.

The univariate results, presented in Section 4.3.2, for Sites 3 and 6 were assessed using one-way ANOVA, and richness and OE50 score results are presented in Figure 7 and Figure 8. Richness and the OE50 score for each site along Porters Ck were found to be significantly different, although not the OE50Signal score.

An assessment of variation using other physical-chemical data for each site revealed no other significant differences between water quality and/or habitat characteristics of each site. However, BVSTEP (**Appendix G**) did highlight five variables which correlated at 0.624, suggesting these variables are contributing to 38.9% of the variation between the sites. The variables included:

- pebble substrate composition (%),
- sand substrate composition (%),
- silt/clay substrate composition (%),
- presence of detritus (%), and
- the presence of branches (%)

The ANOSIM result for Porters Ck, although not statistically significant (*p = 0.100*), presented a considerable difference between the two sites (R = 1.00), and SIMPER revealed a 34.7% dissimilarity between the community data. Taxa contributing to this dissimilarity are presented in Table 12, and include the presence of the indicator taxa – Acarina at Site 6, which was not present at Site 3.

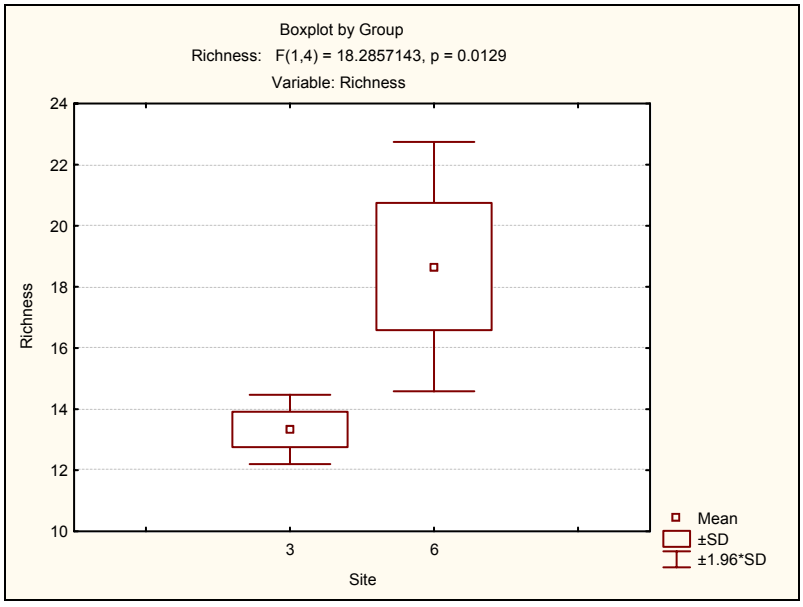


Figure 7: Comparison of sites on Porters Ck using One-Way ANOVA results for Richness, Autumn 2005.

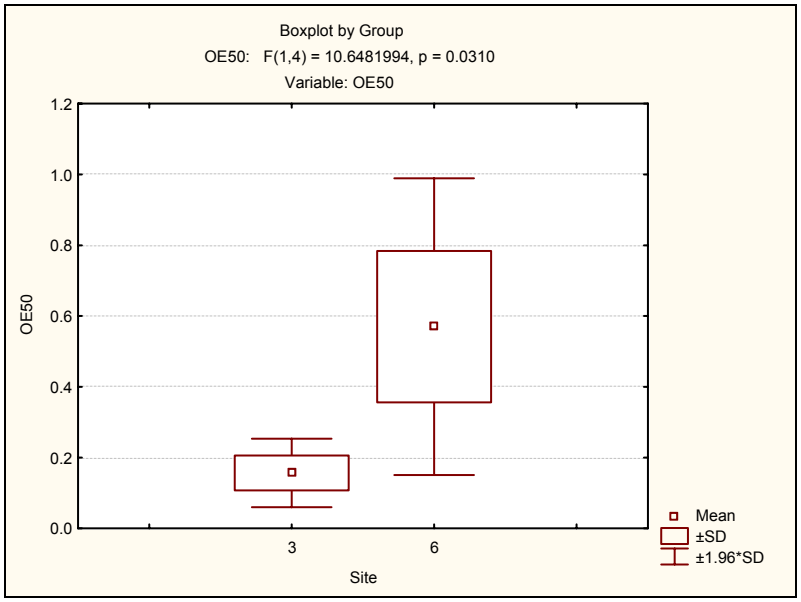


Figure 8: Comparison of sites on Porters Ck using One-Way ANOVA results for OE50 score, Autumn 2005.

Table 12: Significant SIMPER results between two sites along Porters Ck, Autumn 2005. A tick represents the presence of the taxa in at least one of the three replicate samples.

Taxa	Signal Score	Site 3	Site 6
Acarina	6		✓
Aeshnidae	4		✓
Tanypodinae	4		✓
Libellulidae	4		✓
Glossiphonidae	1		✓
Hemicordulidae	5		✓
Ancylidae	4	✓	
Erpobdellidae	1	✓	

Buffalo Ck

The two sites along Buffalo Ck are Site 4, accessed via Robinson Rd, and Site 7 located approximately 250m downstream and accessed through private property at 52 Higginbotham Rd.

The univariate results, presented in Section 4.3.2, for Sites 4 and 7 were assessed using one-way ANOVA and results are presented in Figure 9 and Figure 10. Richness results were considered to be significantly different between the Buffalo Ck sites, although not OE50 or OE50Signal scores.

An assessment of variation using other physical-chemical data for each site revealed that Bedrock substrate composition (%) was significantly different between the sites (df=1,4; F=48.00; *p=0.0023*). BVSTEP also highlighted three variables which correlated at 0.403, suggesting these variables are contributing to 16.2% of the variation between the sites (**Appendix H**). The variables included:

- DO (% saturation),
- Total Alkalinity (mg/L), and
- gravel substrate composition (%)

The ANOSIM result for Buffalo Ck was not statistically significant (*p*=0.30) and resulted in a low R value of 0.204, suggesting minimal differences between the macroinvertebrate composition of each site. SIMPER also indicated a high similarity (79.2%) between the samples; with the only major dissimilarities of five taxa (Table 13).

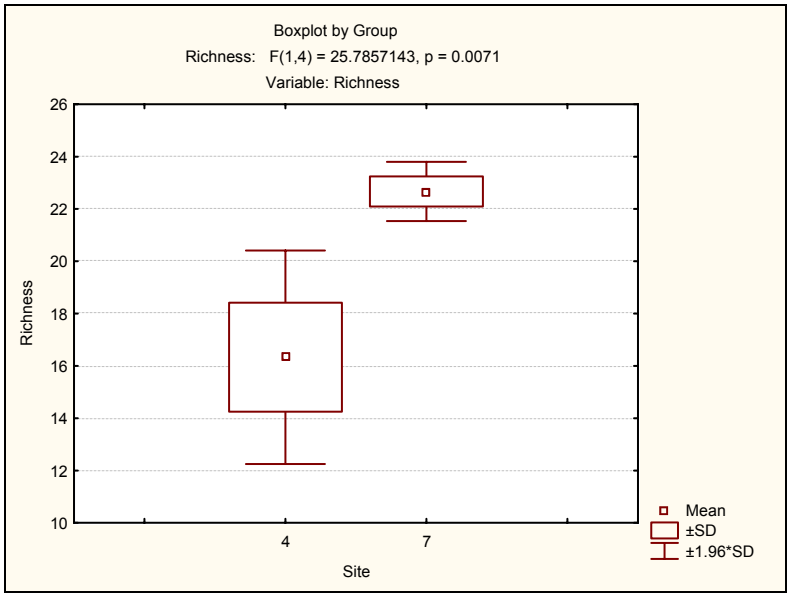


Figure 9: Comparison of sites on Buffalo Ck using One-Way ANOVA results on Richness, Autumn 2005.

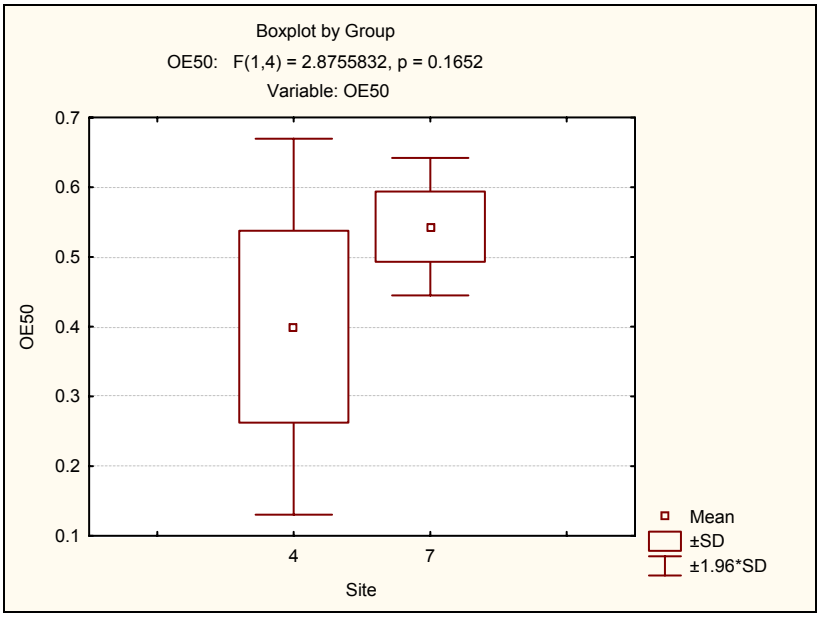


Figure 10:Comparison of sites on Buffalo Ck using One-Way ANOVA results on OE50, Autumn 2005.

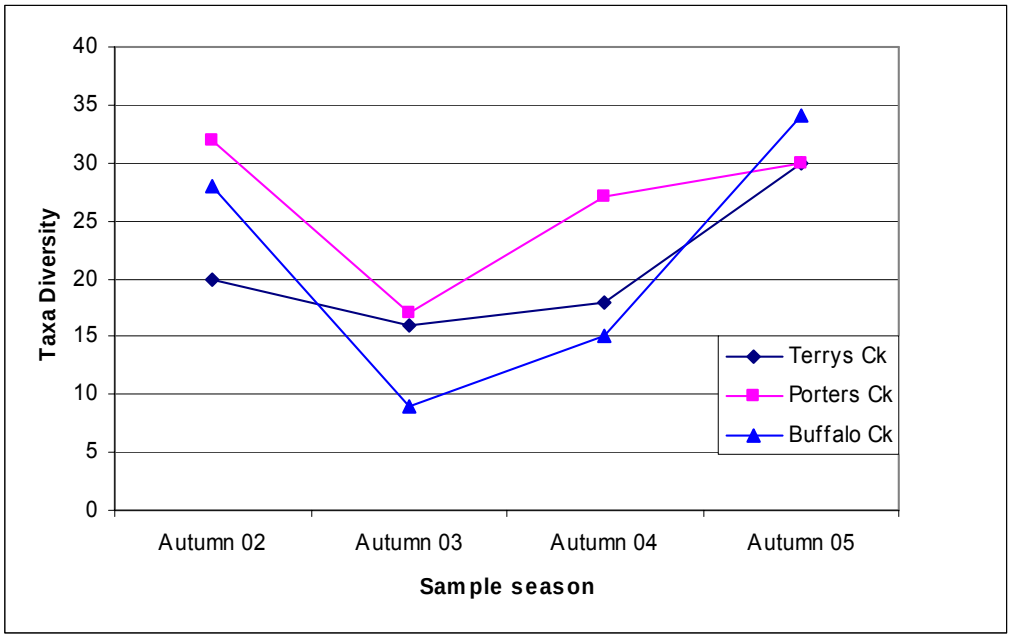
Table 13: Significant SIMPER results between two sites along Buffalo Ck, Autumn 2005. A tick represents the presence of the taxa in at least one of the three replicate samples.

Taxa	Signal Score	Site 4	Site 7
Stratiomyidae	4		✓
Tanypodinae	4		✓
Acarina	6		✓
Corbiculidae	4		✓
Dugesidae	2		✓

Historical Data Comparison

Limited information in each of the previous monitoring reports restricted the level of comparison possible with the current Autumn 2005 data set. Data collected during the Autumn 2005 sampling program from Sites 6 and 7 were used as comparison data to align with historic site locations.

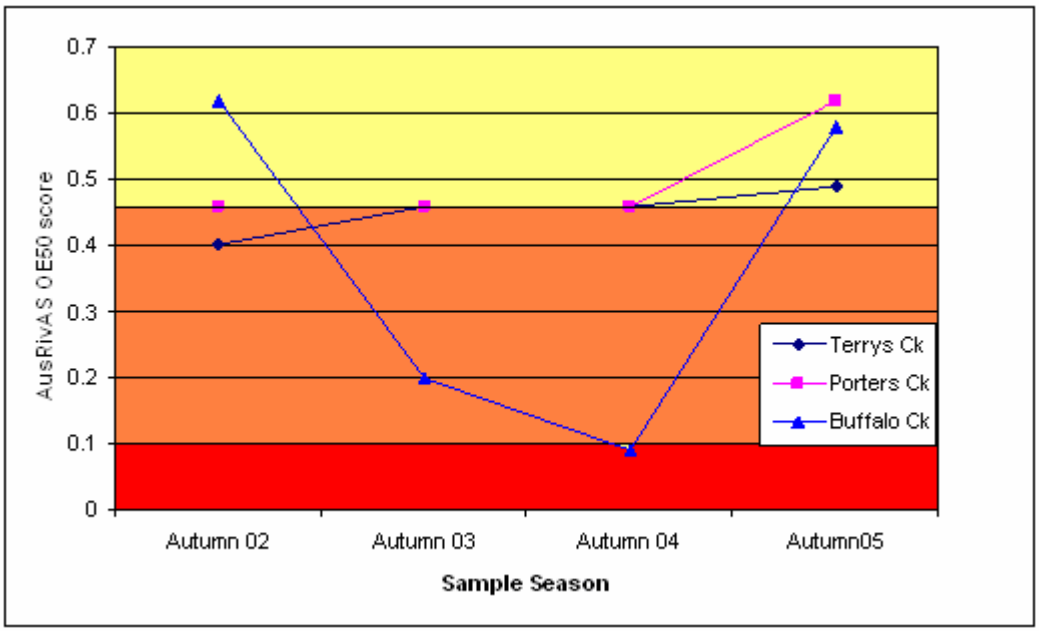
Historical taxa diversity and AusRivAS OE50 scores could be compared between those sites undertaken by Robyn Tuft and Associates (Site 1 – Terry's Ck, Site 6 – Porters Ck, and Site 7 – Buffalo Ck), although with some limitations (Figure 11 and Figure 12). The Robyn Tuft and Associates programs collected single samples during each season, compared with three events over thee months during the Ecowise Autumn 2005 program. For comparative purposes, the Autumn 2005 data was combined for diversity, and averaged for the AusRivAS O/E50 scores.



Data sourced from Robyn Tuft and Associates (2004) report.

Figure 11: Taxa diversity for three of the core sites measured by Robyn Tuft and Associates during Autumn 2002 to Autumn 2004 and Ecowise Autumn 2005, City of Ryde. Ecowise Autumn data was combined for the three events.

The results show an increasing trend in taxa diversity since Autumn 2003, with a significant improvement in results at Buffalo Ck from 15 taxa in 2004 to 34 taxa in 2005. The improved result for Buffalo Ck is also reflected in the O/E50 score for the site during the same time period, from a Band D rating to a Band B rating.



Data sourced from Robyn Tuft and Associates (2004) report.

Figure 12: Comparison of AusRivAS O/E50 scores for the core creeks sampled by Robyn Tuft and Associates in Autumn 2002 to Autumn 2004, and Ecowise Autumn 2005, City of Ryde. Ecowise Autumn 05 AusRivAS O/E50 data was averaged for the three events for this comparison. The AusRivAS bandings (Table 4) are also presented; D – Red, C – Orange, B –Yellow.

5 DISCUSSION

5.1 General Discussion

The results of the Autumn 2005 sampling program indicate that the seven City of Ryde sites are typical of urban creeks with moderate to poor ecological health, dominated by pollution tolerant taxa and poor water quality, including low dissolved oxygen and high nutrient levels. These results are comparable with past sampling events conducted by Robyn Tuft and Associates (2002; 2003a&b; 2004) and BioTrack (2001; 2002; 2004).

Low concentrations of dissolved oxygen can adversely affect many aquatic organisms that depend upon oxygen for their survival (ANZECC and ARMCANZ, 2000). Low dissolved oxygen levels can have a direct (eg. toxic) and an indirect effect (eg. changing the redox potential of soils and releasing Phosphorus into the water column) on biota (ANZECC and ARMCANZ, 2000). Dissolved oxygen regularly fell below the recommended ANZECC and ARMCANZ trigger value of 85% saturation at all sites for at least one sampling event during Autumn 2005 program.

The ANZECC and ARMCANZ (2000) guidelines recommend that even in highly modified ecosystems, dissolved oxygen concentrations, determined over at least one diurnal cycle, should not fall below 60% saturation. However, it must be recognised that under natural conditions dissolved oxygen concentrations can vary considerably over a daily period, and can also be influenced by other water quality variables such as water temperature, salinity, microbial activity and photosynthetic activity. Meaningful interpretation of dissolved oxygen values should be based on data incorporating the full daily range of values, and if possible, the diurnal (daily) range over a few days (ANZECC and ARMCANZ, 2000). The measurements taken during this study provide a ‘snapshot’ of dissolved oxygen values within each creek and are only indicative of conditions prevailing at the time of assessment.

Urban catchments are known to deposit high volumes of nutrients into creeks from stormwater runoff, artificial fertilisers and sediment. Nutrients present in a river system can either be directly toxic to biota (eg. ammonium), or indirectly toxic through a direct effect on other stressors of biota (eg. nutrients which can result in excessive algal growth) (ANZECC and ARMCANZ, 2000). Ammonium levels were recorded above the ANZECC and ARMCANZ (2000) guidelines for all sampling occasions at all sites in Autumn 2005, with several sites measuring over 5 times the recommended trigger level.

Total Nitrogen and Oxidised Nitrogen levels were also much higher than the trigger levels for most sites, although Total Phosphorus was only recorded in exceedence of the trigger level on 4 occasions from 21 samples. The lack of increased algal growth at most sites suggests Phosphorus to be the limiting nutrient in these urban creeks.

Excessive levels of Faecal Coliforms were recorded at most sites during the March event, with Sites 1 and 3 recording 60000 and 28000 orgs/100ml respectively. Faecal Coliform organisms are a measure of bacterial content and recorded levels of over 28 times the secondary contact trigger level is an unacceptable public health risk. A local resident reported to Ecowise staff in May that a strong sewerage smell was coming from a drainage line into Terrys Ck (upstream of Site 1) several months ago and suggested it may have originated behind the block of flats along Crimea Rd. A bucket of animal organs was also found dumped within the riparian zone upstream of Site 3 in March. These external influences (eg. potential sewer overflows and illegal dumpings) may have contributed to the high Faecal Coliforms recorded at these sites. The levels recorded at Sites 1 and 3 during the April and May sampling events were below the primary trigger levels and posed no risk to public health.

All sites were dominated by pollution tolerant taxa, including Oligochaeta – worms (2), Physidae – snails (1), and to a lesser extent Chironominae – biting midges (3). The sites lacked many of the sensitive taxa present in high quality reference condition freshwaters, resulting in AusRivAS bandings of 'B' or lower. This result suggested the sites were significantly impaired with fewer taxa observed than expected, and may be a result of water quality and/or habitat condition. Urban creek catchments are generally impacted by poor/no riparian zones, channelisation, stormwater runoff and human impacts (illegal dumping of weeds, rubbish, contaminants etc), which could all contribute to poor species diversity. Many Chironomidae species are tolerant to heavy metals and the dominance of Chironominae and Oligochaeta in a sample could also suggest organic enrichment (Yandora, 1998). Physidae is an introduced taxa indicative of poor water quality and nutrient enrichment (Gooderham and Tsyrlin, 2003).

Many expected taxa highlighted in the AusRivAS output were found to be missing from the seven sites, which suggested the creeks to be in a degraded state. The absence of these animals indicates poor water quality and poor in-stream habitat diversity. Fourteen of the twenty-one expected (but missing) taxa occurred from families with a low sensitivity to pollution (SIGNAL2 scores <5); however, the presence of several families of Odonata (dragonflies and damsel flies) such as Megapodagrionidae (5) (all sites except Site 2), Hemicordulidae (5) (all sites except Site 2), Coenagrionidae (2) (all sites), and Aeshnidae (4) (Sites 1, 4, 5, 6 and 7), in most samples at all sites suggests the creeks do have a limited capacity to support some larger predatory animals.

The multivariate analyses highlighted differences and similarities between the seven sites, including the separation of samples from Sites 2, 3, and 5 to the remaining samples. The remaining sites were considered to be at least 75% similar in macroinvertebrate community composition. Major taxonomic differences creating the separation of Site 2 samples included the orders Odonata (Megapodagrionidae, Isostictidae, Aeshnidae and Libellulidae), Gastropoda (Hydrobiidae), Diptera (Tanypodinae), and Hemiptera (Notonectidae). Site 3 separated out next in the classification analysis with missing taxa including three of the above taxa and also the indicator taxa 'Acarina'.

5.2 Individual Site Assessments

5.2.1 Site 1: Terrys Ck

Figure 13:Site 1 (Terrys Ck) facing downstream in April 2005.

The Terrys Ck site contained a moderate diversity of macroinvertebrate fauna, with 29 different taxa collected from the edge habitat over the 3 Autumn sampling events. There are a number of microhabitats within the reach including shallow and deep slow-flowing sections, undercut banks, trailing bank vegetation, and shading from riparian vegetation, all of which provide quality habitat for macroinvertebrates.

The AusRivAS results classify the creek as severely (Band 'C') to significantly (Band 'B') impaired, which is an improvement on the Band 'D' and 'C' Spring 2004 results. Taxa differences between Spring and Autumn included the presence of Acarina (6), Aeshnidae (4) Ceinidae (2), Ceratopogonidae (4), Gelastocoridae (5), Tipulidae (4) and Veliidae (1) only in the Autumn results, compared to Ancylidae (4), Atyidae (3), Belostomatidae (1), Hydroptilidae (4) and Lymnaeidae (1) only in Spring results.

Six taxa had a >50% probability of occurrence, but were not collected in any samples from the creek during the Autumn 2005 event. These included the indicator taxa Leptophlebiidae (8) and Leptoceridae (6). Several indicator taxa including Acarina (6), Scirtidae (6) and Elmidae (7), were collected in some samples but were missing from others, suggesting the creek has the capacity to sustain pollution sensitive taxa.

Impacts which may be affecting the presence of more pollution sensitive taxa include low dissolved oxygen levels, poor water quality (stormwater, sewage overflows, illegal discharges etc.) and scouring flows through the system. There is evidence of high flows through this site with scouring along the banks and the presence of rubbish and debris in surrounding riparian vegetation.

5.2.2 Site 2: Shrimptons Ck

Figure 14 Site 2 (Shrimptons Ck) facing upstream in May 2005.

Shrimptons Ck recorded the lowest taxa diversity of the seven sites, totalling 16 different taxa during the Autumn 2005 sampling events, and received the lowest OE50 score, a 0.00 in May. This result was further investigated and was found to be attributed to the lack of Chironomidae observed during the May event. Shrimptons Ck also recorded the lowest dissolved oxygen of all sites and the only pH record below the ANZECC and ARMCANZ (2000) guidelines; however, it did record the lowest Ammonium levels of all sites.

Only 6 taxa were collected during all sampling events in Autumn, and all were considered pollution tolerant taxa (<5 Signal score). There was also an abundance of missing taxa that were expected to be at the site including 4 of the indicator taxa (Acarina, Scirtidae, Leptophlebiidae and Leptoceridae).

Possible impacts causing the overall poor ecological health for Shrimptons Ck include poor water quality (low dissolved oxygen, high nutrients), and potential toxicants in stormwater discharges.

5.2.3 Sites 3 and 6: Porters Ck

Porters Ck is a highly modified system, with the majority of the creek piped underground. Site 3 was located in a small section of Porters Ck that had a semi-natural channel between Epping Rd (adjacent to Wicks Rd) and the Ryde Council Depot. The creek also receives a large volume of discharge from a pipe of unconfirmed origin upstream of Site 3. Site 6 was located downstream of the Ryde Council Depot, within the National Park, where the creek returns to the surface as a natural channel.

The sites, although on the same creek, were distinctly different in physical-chemical parameters and also in biological composition (ANOSIM: R = 1.00; *p=0.10*). Site 3 recorded a combined taxa diversity of 18 which was significantly different to the Site 6 combined taxa diversity of 25. The OE50 scores were also found to be significantly different, with bandings of ‘C’ and ‘D’ for Site 3 and ‘B’ and ‘C’ for Site 6.

The presence of several indicator taxa including Acarina (6), Scirtidae (6), and Leptoceridae (6) were recorded at Site 6 but not found at Site 3, suggesting an improvement of habitat quality downstream allowing the presence of more pollution sensitive taxa to survive. These indicator taxa also contributed to the differences in OE50 bandings between the sites. Site 6 recorded the most taxa consistently observed over the three sampling events (13 taxa) when compared with Site 3 (9 taxa).

Although there were many differences in macroinvertebrate composition between the two sites on Porters Ck, there were no significant differences between the water quality results or habitat variables measured at each site. However, there does appear to be consistent, and to some extent, improved water quality at Site 6 in comparison to the fluctuating results recorded at Site 3. There may be several explanations for this result, including:

- the presence of a treatment device between Sites 3 and 6 (ie. gross pollutant trap or stormwater improvement device),
- the impacts on Site 3 are originating from the point source discharge upstream, and are having a localised impact only which does not continue on downstream to Site 6, and/or
- the drainage line which joins Porters Ck between Sites 3 and 6 is of higher water quality and is providing a dilution effect on the primary water supply.

It may be the case that it is a combination of the above scenarios occurring to improve the ecological health of the creek at Site 6. Overall, Site 6 has proved to be the better of the two sites along Porters Ck and would be the preferred option for future monitoring programs.

Figure 15:Site 3 (Porters Ck at Wicks Rd) upstream in May 2005

Figure 16:Site 6 (Porters Ck downstream of the Ryde Council Depot) downstream in March 2005

5.2.4 Sites 4 and 7: Buffalo Ck

Buffalo Ck borders many residential properties and is highly infested with weed species along the riparian zone, although rehabilitation works is ongoing upstream of Site 4. Sites 4 (upstream) and 7 (downstream) were only 250m apart although did exhibit several differences in water quality and habitat variables.

Figure 17:Site 4 (Buffalo Ck) downstream in May 2005

Figure 18:Site 7 (Buffalo Ck) upstream in May 2005

Visually, Site 4 provided a semi-shaded environment with trailing bank vegetation and undercut banks, while Site 7 presented more an open canopy cleared within metres of the creek's left bank, many riparian weed species and sediment deposits on the creeks outer bends. A higher incidence of algae was present at Site 7 than at Site 4 (Figure 19) during all three sampling events, although was not considered significant.

Figure 19:Presence of algae in a backwater of Buffalo Ck at Site 7 in April 2005.

Taxa diversity was significantly different between sites, with Site 7 recording a combined diversity of 32 taxa, in comparison with 25 at Site 4. Significant differences were found between the percentage of bedrock within the sites (the higher percentage recorded at Site 4), and may have influenced the lower taxa diversity recorded at Site 4 due to the lower availability of softer substrates to burrow into.

O/E50 scores recorded some differences between sites with Site 4 recording bandings of one 'B' and two 'C's, while Site 7 recorded all samples in the AusRivAS Band 'B'. SIMPER results suggested the sites to be 79.2% similar in macroinvertebrate composition, which was also confirmed by the lower ANOSIM result (R = 0.204).

The results present Buffalo Ck to be in moderate ecological health with generally poor water quality (low dissolved oxygen and high nutrients). The major impacts on this creek include residential runoff, current clearing and poisoning of privet upstream of Site 4, scouring flows, and point source discharges from industrial drain located immediately upstream of Site 7. Overall, both sites appear to be directly comparable; however for direct comparisons with historical data, continued sampling of Site 7 is advised for future monitoring programs.

5.2.5 Site 5: Archer Ck

Figure 20:Site 5 (Archer Ck) upstream in March 2005

Archer Ck has had recent restoration works completed on the upstream end of Maze Park, with reconstructed banks using sandstone blocks for stabilisation, and native plant revegetation. Vegetation growth has been steady at this site; however, weeds are still quite dense within the in-stream zones, and on-going maintenance may be necessary to prevent weeds spreading. A number of microhabitats were present at this site including macrophyte beds, trailing bank vegetation and a partially enclosed canopy for half of the reach creating shade.

Archer Ck recorded a combined diversity of 22 taxa, with 12 taxa recorded consistently throughout the Autumn 2005 program. This site also recorded the most consistent O/E50 scores for AusRivAS during the Autumn 2005 program (all Band 'B'), rating the creek as significantly impaired with fewer taxa observed

than expected. Four indicator taxa were expected at this site and only Acarina was collected on two of the three sampling occasions. Also, Baetidae was collected in one sample during the Spring event; however, was missing in all samples in Autumn.

Taxa separating the Site 5 samples from the remaining sites in the multivariate analysis included the lack of Planorbiidae and Hydrobiidae (snails), Isostictidae (damselflies) and Ceinidae (Isopod) taxa, although Dytiscidae (beetle) was present in the Site 5 samples and not in the remaining sites.

5.3 Conclusion

All sites within the City of Ryde study are indicative of urban creeks, with significant to severe impairment of the ecological health. The main influences on these sites, and the creeks on which they are located, include poor water quality (exceeding recommended ANZECC and ARMCANZ, 2000 guidelines), and poor habitat diversity. Biodiversity and ecosystem health results from the Autumn 2005 sampling program are similar to those obtained in earlier monitoring programs, including the previous sampling program in Spring 2004. However, a comparison of results from Autumn from 2002 to 2005 (Robyn Tuft and Associates and Ecowise) for Terrys Ck, Buffalo Ck and Porters Ck indicated an improvement in the ecological health of these creeks in 2005.

Assessment of the sites on Porters Ck illustrated a significant difference between Porters Ck at Wicks Rd (Site 3) and Porters Ck downstream of the Depot (Site 6) in Autumn 2005, with Porters Ck downstream of the Depot (Site 6) in better ecological health. This was most likely the result of improved water quality, as no significant differences in habitat quality were recorded between the two sites.

Few differences existed between the two sites located on Buffalo Ck. Buffalo Ck at Robinson St (Site 4) was in slightly poorer health than Buffalo Ck at Higginbotham Rd (Site 7) and had a greater percentage of bedrock in the substrate; however, the overall results indicated that these sites were, in general, quite similar and thus are directly comparable.

The Autumn 2005 sampling program has demonstrated that the design and methodology adopted for this project are appropriate to achieve the objectives of the City of Ryde program.

6 RECOMMENDATIONS

This program is the second of the City of Ryde's Biological/Chemical Water Quality Monitoring Strategy targeting 5 main creek systems and is to be continued twice yearly over a 7 year period. Following the completion of the Autumn 2005 sampling event it is recommended that :

- The program be modified to target edge habitats only for future macroinvertebrate monitoring, previous results have shown the presence of riffle habitats to be inconsistent within the creeks of the City of Ryde ,

- Continue sampling at the historical site locations 6 and 7 along Porters Ck and Buffalo Ck to align with historical sampling events, and cease sampling at the Spring 2004 site locations (Sites 3 and 4),

- A water quality monitoring program (including event based sampling) be considered to compliment the bi-annual biological program conducted as part of this study to target potential contaminants at the core sites. A comprehensive water quality dataset would also assist with the interpretation of the biological data,

- Further investigation may be warranted into the discharges into Porters Ck from a pipe located on the right bank at the junction of Epping Rd and Wicks Rd, Epping,

- Examine influences such as rainfall and flow in relation to water quality results, and

- Consider compiling all historical raw data (where comparable) for assessment with current study data to provide a temporal evaluation of ecological health of the targeted creeks,

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8 APPENDICES

Appendix A: Macroinvertebrate Results during the Autumn 2005 Sampling Program

	Sample date	30 - 31 March 2005								26 - 27 April 2005								26 - 27 May 2005							
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson St	Buffalo Ck @ 52 Higginbotham	Buffalo Ck @ 52 Higginbotham	Archer Ck @ Maze Park	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Buffalo Ck @ 52 Higginbotham	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Porters Ck @ Depot	Buffalo Ck @ 52 Higginbotham
	Site Code	1	2	3	6	4	7	7	5	1	2	3	6	4	5	7	1	2	3	4	5	6	7
	Habitat	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge
Order	**Family**																						
Acarina		*	*		*		*	*	*						*	*	*			*			*
Amphipoda	**Ceinidae**	*				*										*	*			*			*
Bivalvia	**Corbiculidae**	*	*	*		*	*	*		*	*		*	*		*	*	*	*		*	*	*
Coleoptera	**Dytiscidae**								*						*								
	Elmidae	*								*													
	Hydrophilidae						*																*
	Scirtidae															*	*					*	
Crustacea	**Cladocera**																			*			
	Copepoda		*	*				*	*	*	*	*			*	*							
	Ostracoda		*				*		*	*	*			*	*								
Decapoda	**Atyidae**				*				*						*						*		
Diptera	**Ceratopogonidae**																*						*
	Culicidae			*										*		*							

	Sample date	30 – 31 March 2005										26 – 27 April 2005						26 – 27 May 2005					
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson St	Buffalo Ck @ 52 Higginbotham	Buffalo Ck @ 52 Higginbotham	Archer Ck @ Maze Park	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Buffalo Ck @ 52 Higginbotham	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Porters Ck @ Depot	Buffalo Ck @ 52 Higginbotham
	Site Code	1	2	3	6	4	7	7	5	1	2	3	6	4	5	7	1	2	3	4	5	6	7
	Habitat	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge
Order	**Family**																						
Diptera	**Muscidae**							*															
	s-f Chironominae	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*
	s-f Orthocladiinae	*			*	*	*	*	*		*		*				*						
	s-f Tanypodinae	*			*		*		*	*			*		*	*	*			*	*	*	*
	Simuliidae							*						*									
	Stratiomyidae	*	*				*	*	*	*			*	*	*	*		*			*		*
	Syrphidae						*																
	Tipulidae	*					*	*															
Ephemeroptera	**Baetidae**				*																		
Gastropoda	**Ancylidae**			*	*							*							*				
	Hydrobiidae	*		*	*	*	*	*		*		*	*	*		*	*		*	*		*	*
	Physidae	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Physidae/Planorbidae imm.			*								*			*				*			*	*
	Planorbidae	*	*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*		*	*
Hemiptera	**Corixidae**						*								*						*		
	Gelastocoridae																*	*					
	Gerridae																*						

	Sample date	30 - 31 March 2005								26 - 27 April 2005							26 - 27 May 2005						
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson St	Buffalo Ck @ 52 Higginbotham	Buffalo Ck @ 52 Higginbotham	Archer Ck @ Maze Park	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Buffalo Ck @ 52 Higginbotham	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Porters Ck @ Depot	Buffalo Ck @ 52 Higginbotham
	Site Code	1	2	3	6	4	7	7	5	1	2	3	6	4	5	7	1	2	3	4	5	6	7
	Habitat	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge
Order	**Family**																						
Hemiptera	**Naucoridae**									*													
	Notonectidae	*			*	*	*			*				*		*	*			*	*	*	*
	unidentified					*																	
	Veliidae								*				*		*		*				*		
Hirudinea	**Erpobdellidae**			*				*				*						*	*	*			*
	Glossiphoniidae	*	*		*	*	*	*		*	*		*	*	*	*	*	*	*	*		*	*
Isopoda	**Oniscidae**																			*			
Nematoda				*																			
Odonata	**Aeshnidae**	*			*	*	*		*				*			*				*	*	*	*
	Coenagrionidae		*		*	*	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*
	Epiproctophora						*		*						*								
	H,U,L complex																			*		*	*
	Hemicorduliidae	*		*	*	*	*		*	*	*		*	*	*	*	*		*	*	*	*	*
	Isostictidae	*		*	*					*		*	*			*	*		*			*	*
	Libellulidae				*				*			*	*	*	*	*					*	*	*
	Megapodagrionidae	*		*	*	*	*	*	*	*		*	*	*	*	*	*		*	*	*	*	*
	Synthemistidae															*							
	Zygoptera	*															*	*	*	*		*	

	Sample date	30 - 31 March 2005								26 - 27 April 2005							26 - 27 May 2005						
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson St	Buffalo Ck @ 52 Higginbotham	Buffalo Ck @ 52 Higginbotham	Archer Ck @ Maze Park	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Porters Ck @ Depot	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Buffalo Ck @ 52 Higginbotham	Terrys Ck	Shrimptons Ck	Porters Ck at Wicks Rd	Buffalo Ck @ Robinson	Archer Ck @ Maze Park	Porters Ck @ Depot	Buffalo Ck @ 52 Higginbotham
	Site Code	1	2	3	6	4	7	7	5	1	2	3	6	4	5	7	1	2	3	4	5	6	7
	Habitat	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge
Order	**Family**																						
Oligochaeta		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Trichoptera	**Hydroptilidae**																						*
	Leptoceridae				*																	*	
Turbellaria	**Dugesiidae**	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*		*	*		*

Appendix B: QA Report

QA Report

For: City of Ryde Autumn Sampling Program 2005
Project No.: QE000037

Site Sample Date	Porters Ck @ Wicks Rd Apr-05		Shrimptons Ck Mar-05	
ID	Original	QA	Original	QA
Chironominae	5	4		
Oligochaeta	17	16	10	10
Ostracoda			2	2
Copepoda	1	1	4	2
Acarina			1	
Corbiculidae			9	9
Stratiomyidae			1	1
Ancylidae	1	1		
Physidae/Planorbidae imm.	2	3		
Hydrobiidae	2	2		
Physidae	25	25	17	18
Planorbidae	24	23	11	10
Erpobdellidae	5	5		
Glossiphoniidae			15	15
Coenagrionidae	1	1	1	1
Isostictidae	3	3		
Libellulidae	2	2		
Megapodagrionidae	31	31		
Zygoptera		1		
Dugesiidae	2	2	14	15

identification error counting error

Bray Curtis Similarity (%)		2.07	3.57
Pass or Fail	**PASS**	(avg. 2.82%)	

Comments:

Appendix C: AusRivAS output – Taxa >50% expected and observed

Taxa observed and were >50% expected to be in the edge samples of the seven sites within the City of Ryde, Autumn 2005. Taxa in bold are indicator taxa.

	Taxon Name	**Acarina**	Ostracoda	Atyidae	Dytiscidae	Hydrophilidae	**Scirtidae**	**Elmidae**	Tanypodinae	Orthocladiinae	Chironominae	Veliidae	Gerridae	Notonectidae	Megapodagrionidae	Aeshnidae	**Leptoceridae**
	Signal Score	**6**	5	3	2	2	**6**	**7**	4	4	3	3	4	1	5	4	**6**
Site	**Sampling Event**																
1	March	0.86							0.68		0.8			0.66	0.52	0.55	
	April							0.5	0.74		0.76			0.6			
	May	0.87					0.55		0.69		0.79	0.78	0.76	0.64			
2	March	0.95	0.52														
	April									0.52	0.83						
	May																
3	March										0.82						
	April										0.81				0.54		
	May										0.81				0.57		
4	March										0.81			0.65	0.54	0.54	
	April										0.81			0.67	0.57		
	May	0.86							0.67		0.81			0.67	0.57	0.57	
5	March	0.87		0.62	0.73				0.68		0.81	0.77			0.54	0.54	
	April	0.86		0.62	0.71				0.67		0.81	0.76			0.57		
	May			0.62					0.67		0.81	0.76		0.67	0.57	0.57	
6	March	0.86		0.62					0.67		0.81			0.67	0.57	0.57	1
	April								0.75		0.81	0.84					
	May						0.57		0.67		0.81			0.67	0.57	0.57	1
7	March	0.93				0.59			0.78	0.5	0.83			0.52			
	April	0.92					0.76		0.78		0.83			0.53			
	May	0.89				0.54			0.72		0.81			0.61			

Appendix D: AusRivAS Output – Taxa >50% expected but not observed

Taxa NOT observed but were >50% expected to be in the edge samples of the seven sites within the City of Ryde, Autumn 2005. Taxa in bold are indicator taxa.

	Taxa	**Acarina**	Atyidae	Dytiscidae	Gyrinidae	Hydrophilidae	Hydraenidae	**Scirtidae**	Tanypodinae	Orthocladiinae	Chironominae	**Baetidae**	**Leptophlebiidae**	Mesoveliidae	Hydrometridae	Veliidae	Gerridae	Notonectidae	Aeshnidae	Corduliidae	**Leptoceridae**
	Signal Score	**6**	3	2	4	2	3	**6**	4	4	3	**5**	**8**	2	3	3	4	1	4	5	**6**
Site	**Sampling Event**																				
1	March		0.66	0.71	0.72	0.52		0.55					1			0.77	0.76			0.54	1
	April	0.9	0.78	0.72	0.7	0.66		0.52				0.53	0.97			0.82	0.76				0.97
	May		0.68	0.72	0.71	0.54							0.99						0.52	0.51	0.99
2	March		0.6	0.9		0.63	0.56	0.85	0.82	0.54	0.84		0.78	0.51	0.6	0.91	0.69				0.86
	April	0.94	0.61	0.87		0.61		0.8	0.8				0.82		0.54	0.88	0.7				0.88
	May	0.94	0.61	0.87		0.61		0.8	0.8	0.52	0.83		0.82		0.54	0.88	0.7				0.88
3	March	0.88	0.62	0.76	0.58	0.51		0.64	0.71				0.95			0.8	0.74	0.62		0.54	0.96
	April	0.87	0.62	0.73	0.67			0.59	0.68				0.98			0.77	0.76	0.65	0.54	0.56	0.99
	May	0.86	0.62	0.72	0.71			0.58	0.67				1			0.76	0.76	0.66	0.56	0.57	1
4	March	0.86	0.62	0.73	0.67			0.59	0.68				0.98			0.77	0.76			0.56	0.99
	April	0.86	0.62	0.71	0.71			0.57	0.67				1			0.76	0.76		0.57	0.57	1
	May		0.62	0.71	0.71			0.57					1			0.76	0.76			0.57	1
5	March				0.67			0.6					0.98				0.76	0.65		0.56	0.99
	April				0.71			0.57					1				0.76	0.67	0.57	0.57	1
	May	0.86		0.71	0.71			0.57					1				0.76			0.57	1
6	March			0.71	0.71			0.57					1			0.76	0.76			0.57	
	April	0.91	0.64	0.8		0.58		0.7					0.89				0.73	0.56			0.93
	May	0.86	0.62	0.71	0.71								1			0.76	0.76			0.57	
7	March		0.61	0.85				0.77					0.84		0.5	0.87	0.71				0.9
	April		0.61	0.84		0.58							0.85			0.86	0.71				0.9
	May		0.63	0.76	0.58			0.63					0.94			0.8	0.74			0.52	0.96

Appendix E: SIMPER output – all sites

SIMPER
Similarity Percentages - species contributions

Worksheet

File: T:\Projects\QE000037 City of Ryde BMP\2005 Autumn\Results Stats\Class Ord Bugs.pri
Sample selection: All
Variable selection: All

Parameters

Standardise data: No
Transform: None
Cut off for low contributions: 90.00%
Factor name: Code

Factor groups
1
2
3
4
5
6
7

Group 1

Average similarity: 81.42

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	1.00	5.56	35.99	6.83	6.83
Isostictidae	1.00	5.56	35.99	6.83	13.65
Megapodagrionidae	1.00	5.56	35.99	6.83	20.48
Notonectidae	1.00	5.56	35.99	6.83	27.31
Oligochaeta	1.00	5.56	35.99	6.83	34.13
Physidae	1.00	5.56	35.99	6.83	40.96
Planorbidae	1.00	5.56	35.99	6.83	47.79
Tanypodinae	1.00	5.56	35.99	6.83	54.61
Chironominae	1.00	5.56	35.99	6.83	61.44
Corbiculidae	1.00	5.56	35.99	6.83	68.27
Dugesiidae	1.00	5.56	35.99	6.83	75.09
Glossiphoniidae	1.00	5.56	35.99	6.83	81.92
Hemicorduliidae	1.00	5.56	35.99	6.83	88.75
Stratiomyidae	0.67	1.90	0.58	2.34	91.09

Group 2

Average similarity: 70.91

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Oligochaeta	1.00	9.70	18.48	13.68	13.68
Physidae	1.00	9.70	18.48	13.68	27.35
Planorbidae	1.00	9.70	18.48	13.68	41.03
Corbiculidae	1.00	9.70	18.48	13.68	54.70
Dugesiidae	1.00	9.70	18.48	13.68	68.38
Glossiphoniidae	1.00	9.70	18.48	13.68	82.05
Stratiomyidae	0.67	3.33	0.58	4.70	86.75
Coenagrionidae	0.67	3.33	0.58	4.70	91.45

Group 3

Average similarity: 79.49

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	1.00	7.69	#######	9.68	9.68
Isostictidae	1.00	7.69	#######	9.68	19.35
Megapodagrionidae	1.00	7.69	#######	9.68	29.03
Oligochaeta	1.00	7.69	#######	9.68	38.71

Physidae	1.00	7.69	#######	9.68	48.39
Planorbidae	1.00	7.69	#######	9.68	58.06
Ancylidae	1.00	7.69	#######	9.68	67.74
Chironominae	1.00	7.69	#######	9.68	77.42
Erpobdellidae	1.00	7.69	#######	9.68	87.10
Coenagrionidae	0.67	2.56	0.58	3.23	90.32

Group 4

Average similarity: 74.03

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	1.00	6.53	27.14	8.82	8.82
Megapodagrionidae	1.00	6.53	27.14	8.82	17.64
Notonectidae	1.00	6.53	27.14	8.82	26.45
Oligochaeta	1.00	6.53	27.14	8.82	35.27
Physidae	1.00	6.53	27.14	8.82	44.09
Planorbidae	1.00	6.53	27.14	8.82	52.91
Chironominae	1.00	6.53	27.14	8.82	61.73
Coenagrionidae	1.00	6.53	27.14	8.82	70.54
Glossiphoniidae	1.00	6.53	27.14	8.82	79.36
Hemicorduliidae	1.00	6.53	27.14	8.82	88.18
Aeshnidae	0.67	2.22	0.58	3.00	91.18

Group 5

Average similarity: 81.94

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Libellulidae	1.00	6.00	58.31	7.32	7.32
Megapodagrionidae	1.00	6.00	58.31	7.32	14.65
Oligochaeta	1.00	6.00	58.31	7.32	21.97
Physidae	1.00	6.00	58.31	7.32	29.30
Stratiomyidae	1.00	6.00	58.31	7.32	36.62
Tanypodinae	1.00	6.00	58.31	7.32	43.94
Veliidae	1.00	6.00	58.31	7.32	51.27
Atyidae	1.00	6.00	58.31	7.32	58.59
Chironominae	1.00	6.00	58.31	7.32	65.92
Coenagrionidae	1.00	6.00	58.31	7.32	73.24
Dugesiidae	1.00	6.00	58.31	7.32	80.57
Hemicorduliidae	1.00	6.00	58.31	7.32	87.89
Aeshnidae	0.67	2.02	0.58	2.47	90.36

Group 6

Average similarity: 81.14

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	1.00	5.67	23.43	6.98	6.98
Isostictidae	1.00	5.67	23.43	6.98	13.97
Libellulidae	1.00	5.67	23.43	6.98	20.95
Megapodagrionidae	1.00	5.67	23.43	6.98	27.94
Oligochaeta	1.00	5.67	23.43	6.98	34.92
Physidae	1.00	5.67	23.43	6.98	41.91
Planorbidae	1.00	5.67	23.43	6.98	48.89
Tanypodinae	1.00	5.67	23.43	6.98	55.87
Aeshnidae	1.00	5.67	23.43	6.98	62.86
Chironominae	1.00	5.67	23.43	6.98	69.84
Coenagrionidae	1.00	5.67	23.43	6.98	76.83
Glossiphoniidae	1.00	5.67	23.43	6.98	83.81
Hemicorduliidae	1.00	5.67	23.43	6.98	90.80

Group 7

Average similarity: 83.53

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Hydrobiidae	1.00	4.92	26.30	5.89	5.89
Megapodagrionidae	1.00	4.92	26.30	5.89	11.79
Notonectidae	1.00	4.92	26.30	5.89	17.68
Oligochaeta	1.00	4.92	26.30	5.89	23.57
Physidae	1.00	4.92	26.30	5.89	29.47
Planorbidae	1.00	4.92	26.30	5.89	35.36
Stratiomyidae	1.00	4.92	26.30	5.89	41.26
Tanypodinae	1.00	4.92	26.30	5.89	47.15
Acarina	1.00	4.92	26.30	5.89	53.04
Aeshnidae	1.00	4.92	26.30	5.89	58.94
Chironominae	1.00	4.92	26.30	5.89	64.83

Coenagrionidae	1.00	4.92	26.30	5.89	70.72
Corbiculidae	1.00	4.92	26.30	5.89	76.62
Dugesiidae	1.00	4.92	26.30	5.89	82.51
Glossiphoniidae	1.00	4.92	26.30	5.89	88.41
Hemicorduliidae	1.00	4.92	26.30	5.89	94.30

Groups 1 & 2

Average dissimilarity = 40.35

Species	Group 1 Av.Abund	Group 2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	1.00	0.00	3.54	21.06	8.76	8.76
Isostictidae	1.00	0.00	3.54	21.06	8.76	17.53
Megapodagrionidae	1.00	0.00	3.54	21.06	8.76	26.29
Notonectidae	1.00	0.00	3.54	21.06	8.76	35.05
Tanypodinae	1.00	0.00	3.54	21.06	8.76	43.82
Chironominae	1.00	0.33	2.39	1.33	5.91	49.73
Hemicorduliidae	1.00	0.33	2.39	1.33	5.91	55.64
Ceinidae	0.67	0.00	2.32	1.33	5.74	61.38
Acarina	0.67	0.33	1.96	1.05	4.85	66.24
Orthocladiinae	0.67	0.33	1.96	1.05	4.85	71.09
Ostracoda	0.33	0.67	1.93	1.05	4.79	75.88
Copepoda	0.33	0.67	1.93	1.05	4.79	80.68
Coenagrionidae	0.67	0.67	1.56	0.84	3.87	84.55
Stratiomyidae	0.67	0.67	1.55	0.84	3.83	88.38
Erpobdellidae	0.00	0.33	1.24	0.67	3.06	91.44

Groups 1 & 3

Average dissimilarity = 37.54

Species	Group 1 Av.Abund	Group 3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Notonectidae	1.00	0.00	3.23	35.78	8.60	8.60
Tanypodinae	1.00	0.00	3.23	35.78	8.60	17.20
Ancylidae	0.00	1.00	3.23	35.78	8.60	25.79
Erpobdellidae	0.00	1.00	3.23	35.78	8.60	34.39
Stratiomyidae	0.67	0.00	2.19	1.33	5.82	40.22
Dugesiidae	1.00	0.33	2.15	1.33	5.73	45.95
Glossiphoniidae	1.00	0.33	2.15	1.33	5.73	51.68
Orthocladiinae	0.67	0.00	2.12	1.33	5.64	57.32
Acarina	0.67	0.00	2.12	1.33	5.64	62.96
Ceinidae	0.67	0.00	2.12	1.33	5.64	68.60
Copepoda	0.33	0.67	1.78	1.05	4.75	73.34
Coenagrionidae	0.67	0.67	1.43	0.84	3.82	77.16
Ostracoda	0.33	0.00	1.11	0.67	2.96	80.12
Libellulidae	0.00	0.33	1.08	0.67	2.87	82.99
Corbiculidae	1.00	0.67	1.08	0.67	2.87	85.85
Culicidae	0.00	0.33	1.08	0.67	2.87	88.72
Hemicorduliidae	1.00	0.67	1.08	0.67	2.87	91.59

Groups 2 & 3

Average dissimilarity = 47.56

Species	Group 2 Av.Abund	Group 3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	4.29	22.67	9.03	9.03
Isostictidae	0.00	1.00	4.29	22.67	9.03	18.05
Megapodagrionidae	0.00	1.00	4.29	22.67	9.03	27.08
Ancylidae	0.00	1.00	4.29	22.67	9.03	36.11
Stratiomyidae	0.67	0.00	2.90	1.33	6.11	42.21
Chironominae	0.33	1.00	2.90	1.33	6.11	48.32
Dugesiidae	1.00	0.33	2.86	1.33	6.02	54.34
Glossiphoniidae	1.00	0.33	2.86	1.33	6.02	60.35
Ostracoda	0.67	0.00	2.78	1.33	5.84	66.19
Erpobdellidae	0.33	1.00	2.78	1.33	5.84	72.04
Hemicorduliidae	0.33	0.67	2.40	1.05	5.04	77.08
Copepoda	0.67	0.67	1.94	0.84	4.07	81.15
Coenagrionidae	0.67	0.67	1.89	0.84	3.98	85.13
Libellulidae	0.00	0.33	1.43	0.67	3.01	88.14
Corbiculidae	1.00	0.67	1.43	0.67	3.01	91.15

Groups 1 & 4

Average dissimilarity = 23.32

Species	Group 1 Av.Abund	Group 4 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Isostictidae	1.00	0.00	3.00	24.85	12.88	12.88
Tanypodinae	1.00	0.33	2.02	1.33	8.68	21.56
Stratiomyidae	0.67	0.33	1.69	1.05	7.23	28.79
Aeshnidae	0.33	0.67	1.68	1.05	7.19	35.97
Acarina	0.67	0.33	1.66	1.05	7.14	43.11
Orthocladiinae	0.67	0.33	1.65	1.05	7.06	50.17
Ostracoda	0.33	0.33	1.34	0.84	5.74	55.92
Ceinidae	0.67	0.67	1.34	0.84	5.74	61.66
Dugesiidae	1.00	0.67	1.04	0.67	4.47	66.13
Copepoda	0.33	0.00	1.03	0.67	4.42	70.55
Coenagrionidae	0.67	1.00	1.00	0.67	4.29	74.84
Libellulidae	0.00	0.33	0.98	0.67	4.21	79.05
Corbiculidae	1.00	0.67	0.98	0.67	4.21	83.26
Culicidae	0.00	0.33	0.98	0.67	4.21	87.46
Erpobdellidae	0.00	0.33	0.98	0.67	4.21	91.67

Groups 2 & 4

Average dissimilarity = 42.09

Species	Group 2 Av.Abund	Group 4 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	3.91	17.60	9.28	9.28
Megapodagrionidae	0.00	1.00	3.91	17.60	9.28	18.57
Notonectidae	0.00	1.00	3.91	17.60	9.28	27.85
Aeshnidae	0.00	0.67	2.64	1.33	6.27	34.12
Ceinidae	0.00	0.67	2.64	1.33	6.27	40.39
Chironominae	0.33	1.00	2.64	1.33	6.27	46.66
Hemicorduliidae	0.33	1.00	2.64	1.33	6.27	52.93
Copepoda	0.67	0.00	2.53	1.33	6.02	58.96
Stratiomyidae	0.67	0.33	2.20	1.05	5.22	64.17
Ostracoda	0.67	0.33	2.16	1.05	5.12	69.30
Orthocladiinae	0.33	0.33	1.75	0.84	4.16	73.46
Erpobdellidae	0.33	0.33	1.75	0.84	4.16	77.61
Acarina	0.33	0.33	1.71	0.84	4.07	81.68
Dugesiidae	1.00	0.67	1.37	0.67	3.26	84.94
Libellulidae	0.00	0.33	1.27	0.67	3.01	87.95
Tanypodinae	0.00	0.33	1.27	0.67	3.01	90.97

Groups 3 & 4

Average dissimilarity = 37.28

Species	Group 3 Av.Abund	Group 4 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Isostictidae	1.00	0.00	3.53	27.67	9.48	9.48
Notonectidae	0.00	1.00	3.53	27.67	9.48	18.96
Ancylidae	1.00	0.00	3.53	27.67	9.48	28.44
Aeshnidae	0.00	0.67	2.38	1.33	6.40	34.83
Ceinidae	0.00	0.67	2.38	1.33	6.40	41.23
Erpobdellidae	1.00	0.33	2.38	1.33	6.40	47.62
Copepoda	0.67	0.00	2.36	1.33	6.32	53.94
Glossiphoniidae	0.33	1.00	2.36	1.33	6.32	60.26
Dugesiidae	0.33	0.67	1.94	1.05	5.22	65.47
Libellulidae	0.33	0.33	1.56	0.84	4.19	69.66
Corbiculidae	0.67	0.67	1.56	0.84	4.19	73.85
Culicidae	0.33	0.33	1.56	0.84	4.19	78.04
Orthocladiinae	0.00	0.33	1.23	0.67	3.31	81.35
Coenagrionidae	0.67	1.00	1.18	0.67	3.16	84.51
Hemicorduliidae	0.67	1.00	1.18	0.67	3.16	87.67
Ostracoda	0.00	0.33	1.15	0.67	3.08	90.75

Groups 1 & 5

Average dissimilarity = 36.47

Species	Group 1 Av.Abund	Group 5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	1.00	0.00	2.89	34.54	7.91	7.91
Isostictidae	1.00	0.00	2.89	34.54	7.91	15.83
Libellulidae	0.00	1.00	2.89	34.54	7.91	23.74
Planorbidae	1.00	0.00	2.89	34.54	7.91	31.66
Atyidae	0.00	1.00	2.89	34.54	7.91	39.57
Veliidae	0.33	1.00	1.95	1.33	5.35	44.93
Corixidae	0.00	0.67	1.93	1.33	5.30	50.23

Glossiphoniidae	1.00	0.33	1.93	1.33	5.30	55.53
Notonectidae	1.00	0.33	1.91	1.33	5.23	60.76
Corbiculidae	1.00	0.33	1.91	1.33	5.23	65.98
Ceinidae	0.67	0.00	1.90	1.33	5.20	71.18
Aeshnidae	0.33	0.67	1.61	1.05	4.41	75.59
Orthocladiinae	0.67	0.33	1.60	1.05	4.38	79.97
Ostracoda	0.33	0.67	1.59	1.05	4.36	84.32
Copepoda	0.33	0.67	1.59	1.05	4.36	88.68
Acarina	0.67	0.67	1.30	0.84	3.56	92.24

Groups 2 & 5

Average dissimilarity = 49.20

Species	Group 2 Av.Abund	Group 5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Libellulidae	0.00	1.00	3.71	23.58	7.54	7.54
Megapodagrionidae	0.00	1.00	3.71	23.58	7.54	15.08
Planorbidae	1.00	0.00	3.71	23.58	7.54	22.62
Tanypodinae	0.00	1.00	3.71	23.58	7.54	30.16
Veliidae	0.00	1.00	3.71	23.58	7.54	37.70
Atyidae	0.00	1.00	3.71	23.58	7.54	45.24
Chironominae	0.33	1.00	2.50	1.33	5.09	50.33
Hemicorduliidae	0.33	1.00	2.50	1.33	5.09	55.42
Aeshnidae	0.00	0.67	2.49	1.33	5.06	60.48
Corixidae	0.00	0.67	2.49	1.33	5.06	65.54
Glossiphoniidae	1.00	0.33	2.49	1.33	5.06	70.59
Corbiculidae	1.00	0.33	2.44	1.33	4.96	75.56
Acarina	0.33	0.67	2.06	1.05	4.19	79.75
Ostracoda	0.67	0.67	1.68	0.84	3.41	83.16
Copepoda	0.67	0.67	1.68	0.84	3.41	86.57
Orthocladiinae	0.33	0.33	1.63	0.84	3.32	89.88
Erpobdellidae	0.33	0.00	1.30	0.67	2.64	92.52

Groups 3 & 5

Average dissimilarity = 54.30

Species	Group 3 Av.Abund	Group 5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	1.00	0.00	3.37	58.67	6.21	6.21
Isostictidae	1.00	0.00	3.37	58.67	6.21	12.42
Planorbidae	1.00	0.00	3.37	58.67	6.21	18.63
Stratiomyidae	0.00	1.00	3.37	58.67	6.21	24.84
Tanypodinae	0.00	1.00	3.37	58.67	6.21	31.04
Veliidae	0.00	1.00	3.37	58.67	6.21	37.25
Ancylidae	1.00	0.00	3.37	58.67	6.21	43.46
Atyidae	0.00	1.00	3.37	58.67	6.21	49.67
Erpobdellidae	1.00	0.00	3.37	58.67	6.21	55.88
Aeshnidae	0.00	0.67	2.26	1.33	4.16	60.04
Corixidae	0.00	0.67	2.26	1.33	4.16	64.21
Libellulidae	0.33	1.00	2.25	1.33	4.14	68.34
Dugesiidae	0.33	1.00	2.25	1.33	4.14	72.48
Ostracoda	0.00	0.67	2.22	1.33	4.09	76.58
Acarina	0.00	0.67	2.22	1.33	4.09	80.67
Corbiculidae	0.67	0.33	1.86	1.05	3.43	84.10
Copepoda	0.67	0.67	1.51	0.84	2.78	86.88
Glossiphoniidae	0.33	0.33	1.49	0.84	2.75	89.63
Notonectidae	0.00	0.33	1.15	0.67	2.12	91.75

Groups 4 & 5

Average dissimilarity = 40.39

Species	Group 4 Av.Abund	Group 5 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	1.00	0.00	3.13	28.05	7.75	7.75
Planorbidae	1.00	0.00	3.13	28.05	7.75	15.49
Veliidae	0.00	1.00	3.13	28.05	7.75	23.24
Atyidae	0.00	1.00	3.13	28.05	7.75	30.98
Libellulidae	0.33	1.00	2.11	1.33	5.22	36.20
Stratiomyidae	0.33	1.00	2.11	1.33	5.22	41.42
Tanypodinae	0.33	1.00	2.11	1.33	5.22	46.64
Ceinidae	0.67	0.00	2.11	1.33	5.22	51.86
Corixidae	0.00	0.67	2.10	1.33	5.19	57.05
Glossiphoniidae	1.00	0.33	2.10	1.33	5.19	62.24
Notonectidae	1.00	0.33	2.06	1.33	5.11	67.35
Copepoda	0.00	0.67	2.06	1.33	5.11	72.46

Ostracoda	0.33	0.67	1.74	1.05	4.30	76.76
Acarina	0.33	0.67	1.74	1.05	4.30	81.07
Corbiculidae	0.67	0.33	1.74	1.05	4.30	85.37
Orthocladiinae	0.33	0.33	1.40	0.84	3.47	88.84
Aeshnidae	0.67	0.67	1.38	0.84	3.41	92.25

Groups 1 & 6

Average dissimilarity = 20.90

Species	Group 1 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Libellulidae	0.00	1.00	2.81	22.28	13.44	13.44
Aeshnidae	0.33	1.00	1.87	1.33	8.96	22.40
Ceinidae	0.67	0.00	1.85	1.33	8.83	31.24
Stratiomyidae	0.67	0.33	1.57	1.05	7.53	38.76
Acarina	0.67	0.33	1.56	1.05	7.47	46.24
Orthocladiinae	0.67	0.67	1.27	0.84	6.08	52.32
Scirtidae	0.33	0.33	1.26	0.84	6.01	58.33
Veliidae	0.33	0.33	1.24	0.84	5.91	64.24
Dugesiidae	1.00	0.67	0.98	0.67	4.69	68.94
Ostracoda	0.33	0.00	0.96	0.67	4.61	73.54
Copepoda	0.33	0.00	0.96	0.67	4.61	78.15
Coenagrionidae	0.67	1.00	0.94	0.67	4.48	82.63
Notonectidae	1.00	0.67	0.93	0.67	4.43	87.06
Ancylidae	0.00	0.33	0.90	0.67	4.31	91.37

Groups 2 & 6

Average dissimilarity = 48.48

Species	Group 2 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	3.58	16.47	7.39	7.39
Isostictidae	0.00	1.00	3.58	16.47	7.39	14.78
Libellulidae	0.00	1.00	3.58	16.47	7.39	22.17
Megapodagrionidae	0.00	1.00	3.58	16.47	7.39	29.56
Tanypodinae	0.00	1.00	3.58	16.47	7.39	36.95
Aeshnidae	0.00	1.00	3.58	16.47	7.39	44.34
Chironominae	0.33	1.00	2.42	1.33	4.99	49.33
Hemicorduliidae	0.33	1.00	2.42	1.33	4.99	54.31
Notonectidae	0.00	0.67	2.41	1.33	4.96	59.27
Ostracoda	0.67	0.00	2.33	1.33	4.81	64.08
Copepoda	0.67	0.00	2.33	1.33	4.81	68.89
Stratiomyidae	0.67	0.33	2.01	1.05	4.14	73.02
Orthocladiinae	0.33	0.67	1.97	1.05	4.07	77.09
Acarina	0.33	0.33	1.56	0.84	3.22	80.32
Scirtidae	0.00	0.33	1.27	0.67	2.61	82.93
Dugesiidae	1.00	0.67	1.27	0.67	2.61	85.54
Erpobdellidae	0.33	0.00	1.25	0.67	2.58	88.13
Veliidae	0.00	0.33	1.18	0.67	2.43	90.56

Groups 3 & 6

Average dissimilarity = 34.74

Species	Group 3 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Tanypodinae	0.00	1.00	3.27	22.80	9.40	9.40
Aeshnidae	0.00	1.00	3.27	22.80	9.40	18.80
Erpobdellidae	1.00	0.00	3.27	22.80	9.40	28.20
Ancylidae	1.00	0.33	2.22	1.33	6.40	34.61
Notonectidae	0.00	0.67	2.19	1.33	6.31	40.91
Libellulidae	0.33	1.00	2.18	1.33	6.27	47.18
Copepoda	0.67	0.00	2.18	1.33	6.27	53.45
Glossiphoniidae	0.33	1.00	2.18	1.33	6.27	59.71
Orthocladiinae	0.00	0.67	2.12	1.33	6.09	65.81
Dugesiidae	0.33	0.67	1.79	1.05	5.16	70.97
Corbiculidae	0.67	0.67	1.44	0.84	4.13	75.11
Scirtidae	0.00	0.33	1.15	0.67	3.31	78.41
Coenagrionidae	0.67	1.00	1.09	0.67	3.13	81.55
Culicidae	0.33	0.00	1.09	0.67	3.13	84.68
Hemicorduliidae	0.67	1.00	1.09	0.67	3.13	87.81
Stratiomyidae	0.00	0.33	1.08	0.67	3.09	90.91

Groups 4 & 6

Average dissimilarity = 25.18

Species	Group 4 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Isostictidae	0.00	1.00	3.04	19.50	12.06	12.06
Libellulidae	0.33	1.00	2.05	1.33	8.12	20.18
Tanypodinae	0.33	1.00	2.05	1.33	8.12	28.31
Ceinidae	0.67	0.00	2.05	1.33	8.12	36.43
Orthocladiinae	0.33	0.67	1.66	1.05	6.59	43.02
Dugesiidae	0.67	0.67	1.38	0.84	5.47	48.49
Stratiomyidae	0.33	0.33	1.34	0.84	5.32	53.81
Acarina	0.33	0.33	1.33	0.84	5.27	59.08
Corbiculidae	0.67	0.67	1.33	0.84	5.27	64.36
Scirtidae	0.00	0.33	1.06	0.67	4.23	68.59
Notonectidae	1.00	0.67	1.00	0.67	3.97	72.56
Veliidae	0.00	0.33	1.00	0.67	3.97	76.53
Ostracoda	0.33	0.00	0.99	0.67	3.94	80.47
Aeshnidae	0.67	1.00	0.99	0.67	3.94	84.41
Culicidae	0.33	0.00	0.99	0.67	3.94	88.35
Erpobdellidae	0.33	0.00	0.99	0.67	3.94	92.28

Groups 5 & 6

Average dissimilarity = 32.82

Species	Group 5 Av.Abund	Group 6 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	2.92	23.91	8.89	8.89
Isostictidae	0.00	1.00	2.92	23.91	8.89	17.78
Planorbidae	0.00	1.00	2.92	23.91	8.89	26.67
Atyidae	1.00	0.33	1.98	1.33	6.04	32.71
Stratiomyidae	1.00	0.33	1.96	1.33	5.96	38.66
Veliidae	1.00	0.33	1.96	1.33	5.96	44.62
Corixidae	0.67	0.00	1.95	1.33	5.95	50.58
Glossiphoniidae	0.33	1.00	1.95	1.33	5.95	56.53
Ostracoda	0.67	0.00	1.93	1.33	5.87	62.40
Copepoda	0.67	0.00	1.93	1.33	5.87	68.27
Acarina	0.67	0.33	1.63	1.05	4.95	73.22
Corbiculidae	0.33	0.67	1.63	1.05	4.95	78.17
Notonectidae	0.33	0.67	1.62	1.05	4.93	83.10
Orthocladiinae	0.33	0.67	1.61	1.05	4.90	88.00
Scirtidae	0.00	0.33	1.02	0.67	3.11	91.11

Groups 1 & 7

Average dissimilarity = 16.52

Species	Group 1 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Aeshnidae	0.33	1.00	1.74	1.33	10.55	10.55
Libellulidae	0.00	0.67	1.71	1.33	10.36	20.91
Orthocladiinae	0.67	0.33	1.43	1.05	8.69	29.60
Ostracoda	0.33	0.33	1.18	0.84	7.13	36.73
Ceinidae	0.67	0.67	1.18	0.84	7.13	43.86
Copepoda	0.33	0.33	1.16	0.84	7.01	50.87
Scirtidae	0.33	0.33	1.14	0.84	6.90	57.77
Isostictidae	1.00	0.67	0.90	0.67	5.46	63.23
Corixidae	0.00	0.33	0.90	0.67	5.46	68.68
Acarina	0.67	1.00	0.89	0.67	5.41	74.10
Erpobdellidae	0.00	0.33	0.88	0.67	5.31	79.41
Coenagrionidae	0.67	1.00	0.87	0.67	5.27	84.68
Stratiomyidae	0.67	1.00	0.85	0.67	5.14	89.82
Veliidae	0.33	0.00	0.85	0.67	5.14	94.95

Groups 2 & 7

Average dissimilarity = 41.22

Species	Group 2 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	3.27	18.44	7.93	7.93
Megapodagrionidae	0.00	1.00	3.27	18.44	7.93	15.86
Notonectidae	0.00	1.00	3.27	18.44	7.93	23.79
Tanypodinae	0.00	1.00	3.27	18.44	7.93	31.72
Aeshnidae	0.00	1.00	3.27	18.44	7.93	39.65
Acarina	0.33	1.00	2.20	1.33	5.35	45.00
Chironominae	0.33	1.00	2.20	1.33	5.35	50.35
Hemicorduliidae	0.33	1.00	2.20	1.33	5.35	55.69
Isostictidae	0.00	0.67	2.13	1.33	5.17	60.86

Libellulidae	0.00	0.67	2.13	1.33	5.17	66.04
Ceinidae	0.00	0.67	2.13	1.33	5.17	71.21
Copepoda	0.67	0.33	1.82	1.05	4.41	75.61
Ostracoda	0.67	0.33	1.79	1.05	4.34	79.95
Erpobdellidae	0.33	0.33	1.47	0.84	3.57	83.52
Orthocladiinae	0.33	0.33	1.46	0.84	3.55	87.07
Corixidae	0.00	0.33	1.14	0.67	2.76	89.82
Stratiomyidae	0.67	1.00	1.07	0.67	2.58	92.41

Groups 3 & 7

Average dissimilarity = 38.77

Species	Group 3 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Notonectidae	0.00	1.00	3.00	25.54	7.75	7.75
Stratiomyidae	0.00	1.00	3.00	25.54	7.75	15.50
Tanypodinae	0.00	1.00	3.00	25.54	7.75	23.25
Acarina	0.00	1.00	3.00	25.54	7.75	30.99
Aeshnidae	0.00	1.00	3.00	25.54	7.75	38.74
Ancylidae	1.00	0.00	3.00	25.54	7.75	46.49
Dugesiidae	0.33	1.00	2.00	1.33	5.17	51.66
Glossiphoniidae	0.33	1.00	2.00	1.33	5.17	56.82
Erpobdellidae	1.00	0.33	1.99	1.33	5.14	61.97
Ceinidae	0.00	0.67	1.96	1.33	5.06	67.03
Copepoda	0.67	0.33	1.69	1.05	4.35	71.38
Libellulidae	0.33	0.67	1.66	1.05	4.27	75.65
Culicidae	0.33	0.33	1.32	0.84	3.40	79.05
Isostictidae	1.00	0.67	1.04	0.67	2.69	81.73
Orthocladiinae	0.00	0.33	1.04	0.67	2.69	84.42
Ostracoda	0.00	0.33	1.04	0.67	2.69	87.11
Corixidae	0.00	0.33	1.04	0.67	2.69	89.79
Coenagrionidae	0.67	1.00	1.00	0.67	2.58	92.38

Groups 4 & 7

Average dissimilarity = 20.88

Species	Group 4 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stratiomyidae	0.33	1.00	1.89	1.33	9.05	9.05
Tanypodinae	0.33	1.00	1.89	1.33	9.05	18.11
Acarina	0.33	1.00	1.89	1.33	9.05	27.16
Isostictidae	0.00	0.67	1.84	1.33	8.80	35.96
Libellulidae	0.33	0.67	1.55	1.05	7.44	43.40
Orthocladiinae	0.33	0.33	1.27	0.84	6.08	49.48
Ostracoda	0.33	0.33	1.26	0.84	6.01	55.49
Ceinidae	0.67	0.67	1.26	0.84	6.01	61.50
Erpobdellidae	0.33	0.33	1.25	0.84	5.96	67.46
Culicidae	0.33	0.33	1.23	0.84	5.88	73.34
Dugesiidae	0.67	1.00	0.97	0.67	4.65	78.00
Corixidae	0.00	0.33	0.97	0.67	4.65	82.65
Aeshnidae	0.67	1.00	0.92	0.67	4.40	87.05
Corbiculidae	0.67	1.00	0.92	0.67	4.40	91.44

Groups 5 & 7

Average dissimilarity = 30.84

Species	Group 5 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hydrobiidae	0.00	1.00	2.71	26.39	8.77	8.77
Planorbidae	0.00	1.00	2.71	26.39	8.77	17.55
Veliidae	1.00	0.00	2.71	26.39	8.77	26.32
Atyidae	1.00	0.00	2.71	26.39	8.77	35.10
Glossiphoniidae	0.33	1.00	1.81	1.33	5.88	40.98
Notonectidae	0.33	1.00	1.79	1.33	5.80	46.77
Corbiculidae	0.33	1.00	1.79	1.33	5.80	52.57
Isostictidae	0.00	0.67	1.77	1.33	5.74	58.31
Ceinidae	0.00	0.67	1.77	1.33	5.74	64.06
Copepoda	0.67	0.33	1.51	1.05	4.90	68.95
Corixidae	0.67	0.33	1.49	1.05	4.85	73.80
Ostracoda	0.67	0.33	1.49	1.05	4.82	78.63
Orthocladiinae	0.33	0.33	1.21	0.84	3.93	82.55
Libellulidae	1.00	0.67	0.93	0.67	3.03	85.58
Acarina	0.67	1.00	0.92	0.67	2.98	88.56
Erpobdellidae	0.00	0.33	0.91	0.67	2.95	91.51

Groups 6 & 7

Average dissimilarity = 19.31

Species	Group 6 Av.Abund	Group 7 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Acarina	0.33	1.00	1.79	1.33	9.26	9.26
Stratiomyidae	0.33	1.00	1.77	1.33	9.15	18.41
Ceinidae	0.00	0.67	1.73	1.33	8.94	27.35
Orthocladiinae	0.67	0.33	1.44	1.05	7.47	34.83
Scirtidae	0.33	0.33	1.17	0.84	6.08	40.91
Dugesiidae	0.67	1.00	0.92	0.67	4.76	45.66
Isostictidae	1.00	0.67	0.91	0.67	4.71	50.38
Libellulidae	1.00	0.67	0.91	0.67	4.71	55.09
Ostracoda	0.00	0.33	0.91	0.67	4.71	59.80
Corixidae	0.00	0.33	0.91	0.67	4.71	64.51
Erpobdellidae	0.00	0.33	0.89	0.67	4.59	69.10
Notonectidae	0.67	1.00	0.87	0.67	4.51	73.61
Veliidae	0.33	0.00	0.87	0.67	4.51	78.11
Ancylidae	0.33	0.00	0.85	0.67	4.39	82.51
Atyidae	0.33	0.00	0.85	0.67	4.39	86.90
Corbiculidae	0.67	1.00	0.85	0.67	4.39	91.29

Appendix F: BVSTEP output – all sites

BVSTEP
Biota and/or Environment matching

Worksheet

File: T:\Projects\QE000037 City of Ryde BMP\2005 Autumn\New Results Stats\BVSTEP - habitat data.xls
Sample selection: All
Variable selection: All

Similarity Matrix

File: Sheet1
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Termination criteria:
rho > 0.95
delta rho < 0.001
Use random selection for starting variables
Number of restarts: 10
Percentage of starting variables: 50

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

Variables

1 Water Temp
2 Conductivity
3 pH
4 DO
5 DO (%sat.)
6 Turbidity
7 Bedrock
8 Boulder
9 Cobble
10 Pebble
11 Gravel
12 Sand
13 Silt/clay
14 detritus
15 sticks
16 branches
17 logs
18 algae
19 macrophytes
20 TDS (mg/L)
21 TN (µg/L)
22 TKN (µg/L)
23 NOx (µg/L)
24 TP (µg/L)
25 Ammonium (µg/L)
26 Faecal Coliforms
27 Total Alk. (CaCO3)

Best results

No. Vars	Corr.	Selections
8	0.449	1,3,10-13,16,19
9	0.241	9-11,13,14,16,17,26,27
6	0.240	9,13,14,19,26,27

Appendix G: BVSTEP output – Porters Ck sites

BVSTEP

Biota and/or Environment matching

Worksheet

File: T:\Projects\QE000037 City of Ryde BMP\2005 Autumn\New Results Stats\BVSTEP - habitat data.xls
Sample selection: All
Variable selection: All

Similarity Matrix

File: Sheet2
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Termination criteria:
rho > 0.95
delta rho < 0.001
Use random selection for starting variables
Number of restarts: 10
Percentage of starting variables: 50

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

Variables

1	Water Temp	15	sticks
2	Conductivity	16	branches
3	pH	17	logs
4	DO	18	algae
5	DO (%sat.)	19	macrophytes
6	Turbidity	20	TDS (mg/L)
7	Bedrock	21	TN (µg/L)
8	Boulder	22	TKN (µg/L)
9	Cobble	23	NOx (µg/L)
10	Pebble	24	TP (µg/L)
11	Gravel	25	Ammonium (µg/L)
12	Sand	26	Faecal Coliforms
13	Silt/clay	27	Total Alk. (CaCO3)
14	detritus		

Best results

No. Vars	Corr.	Selections
5	0.624	10,12-14,16
5	0.606	3,11,13,14,16
4	0.587	9,12,14,16

Appendix H: BVSTEP output – Buffalo Ck sites

BVSTEP
Biota and/or Environment matching

Worksheet

File: T:\Projects\QE000037 City of Ryde BMP\2005 Autumn\New Results Stats\BVSTEP - habitat data.xls
Sample selection: All
Variable selection: All

Similarity Matrix

File: Sheet1
Data type: Similarities
Sample selection: All

Parameters

Rank correlation method: Spearman
Termination criteria:
rho > 0.95
delta rho < 0.001
Use random selection for starting variables
Number of restarts: 10
Percentage of starting variables: 50

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

Variables

1 Water Temp
2 Conductivity
3 pH
4 DO
5 DO (%sat.)
6 Turbidity
7 Bedrock
8 Boulder
9 Cobble
10 Pebble
11 Gravel
12 Sand
13 Silt/clay
14 detritus
15 sticks
16 branches
17 logs
18 algae
19 macrophytes
20 TDS (mg/L)
21 TN (µg/L)
22 TKN (µg/L)
23 NOx (µg/L)
24 TP (µg/L)
25 Ammonium (µg/L)
26 Faecal Coliforms
27 Total Alk. (CaCO3)

Best results

No. Vars	Corr.	Selections
3	0.403	5,11,27
6	0.297	5,7,13,14,19,27
4	0.222	7,20,24,25
4	0.107	2,18,20,22
4	0.107	2,6,20,22
4	0.079	2,20,21,26