FINAL REPORT

“Biological and Water Quality Monitoring of Five Core Sites in Spring 2004”

Contract No. EP/WQM/E1/04

for
City of Ryde

March 2005

March 2005

Contact for further Information:

Grant Leslie

NSW Manager
Sydney Office
Telephone: +61 2 4721 3477
Facsimile: +61 2 4721 5699
Email: gleslie@ecowise.com.au

ECOWISE Environmental ABN 68 074 205 780

Brisbane Office
Unit 2/49 Butterfield St
Herston QLD 4006
PO Box 673
Spring Hill QLD 4004
Telephone: +61 7 3854 0233
Facsimile: +61 7 3854 0288

Canberra Office
16A Lithgow St
PO Box 1834
Fyshwick ACT 2609
Telephone: +61 2 6270 7650
Facsimile: +61 2 6270 7631

Sydney Office
24 Lemko Place
Penrith NSW 2750
Telephone: +61 2 4721 3477
Facsimile: +61 2 4721 5699

Perth Office
Unit 2 / 4 Milson Place
O'Connor WA 6163
Telephone: +61 8 9337 4166
Facsimile: +61 8 9337 4577

Authors:

Kim Piercy
Nirvana Searle

ECOWISE Quality Reference No.: QE000037

File Reference: T:\ Projects\QE000037 City of Ryde Biological & Water Quality Monitoring Project 2004.doc

29th March 2005

Report No. 2004/122

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 this program of biological and water quality monitoring of 5 key urban creek systems within its area of operations. A seven year strategy has been developed to 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 community 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 the City of Ryde to conduct the first sampling event in Spring 2004 as part of the 7 year Biological/Chemical Monitoring Strategy. Core sampling sites were selected by Council and included :

- Site 1 – Terrys Ck near the M2 motorway at the end of Somerset Rd, North Epping,
- Site 2 – Shrimptons Ck at Wilga Park,
- Site 3 – Porters Ck just before the stream becomes piped under the North Ryde Transfer Station,
- Site 4 – Buffalo Ck at Higginbotham Rd, and
- Site 5 – Archer Ck at Maze Park.

Sampling was conducted in September (14th & 15th), October (11th & 12th) and November (23rd & 24th) 2004 with each sampling event separated by around 4 weeks as required by the City of Ryde. 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 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 recommended ANZECC and ARMCANZ (2000) guideline values across all sites for all sampling events. Conductivity (salinity) in Porters Creek (site 3) was recorded at 11,040 µS/cm in September which greatly exceeds recommended ANZECC and ARMCANZ (2000) guidelines for ecosystem protection and appeared to be related to a discharge from a nearby stormwater pipe. Both faecal coliform and total phosphorus results also exceeded ANZECC and ARMCANZ (2000) guidelines for all sites on most sampling occasions in Spring 2004, with Porters Creek (site 3) regularly exceeding primary and secondary recreational water quality and aesthetic guidelines (ANZECC and ARMCANZ, 2000) for faecal coliforms.

A total of 48 different families were recorded over the three Spring sampling events with insects the most dominant (33 taxa), followed by gastropods (5 taxa), crustaceans (3 taxa) and bivalves (2 taxa).

After 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 analyses allow comparisons between sites based upon the community structure.

All of the 5 core sites in the City of Ryde study were found to be indicative of urban creeks generally, dominated by pollution tolerant taxa with many expected taxa missing. AusRivAS modelling classified the 5 core sites as being in poor ecological health with severe to extreme impairment. The main influences on the creeks include poor water quality and poor habitat diversity. The results and trends for biodiversity and ecosystem health obtained from the Spring 2004 sampling event are generally consistent with those obtained from earlier monitoring programs. These results would suggest that the 5 monitoring sites have neither improved nor deteriorated in health over this period.

The Spring 2004 sampling event has demonstrated that the design and methodology adopted for this project are appropriate to achieve the objectives of the City of Ryde program.

TABLE OF CONTENTS

List of Figures

List of Tables

1 INTRODUCTION

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. The Urban Research and Development Program of the NRHP 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 interrelated forms of disturbance or degradation that can affect stream ecology, including :

- 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 to commence in September 2004 and 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 will enable the City of Ryde to (COR Quotation No.: EP/WQM/E1/04):

- 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 sampling program for the Biological/Chemical Water Quality Monitoring Strategy in Spring 2004.

1.2 Scope of Works

The scope of works for the Spring 2004 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 Spring 2004 only (September, October and November). 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.

1.3 Previous sampling programs

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

<u>Shrimptons and Archer Creeks</u>

- 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.

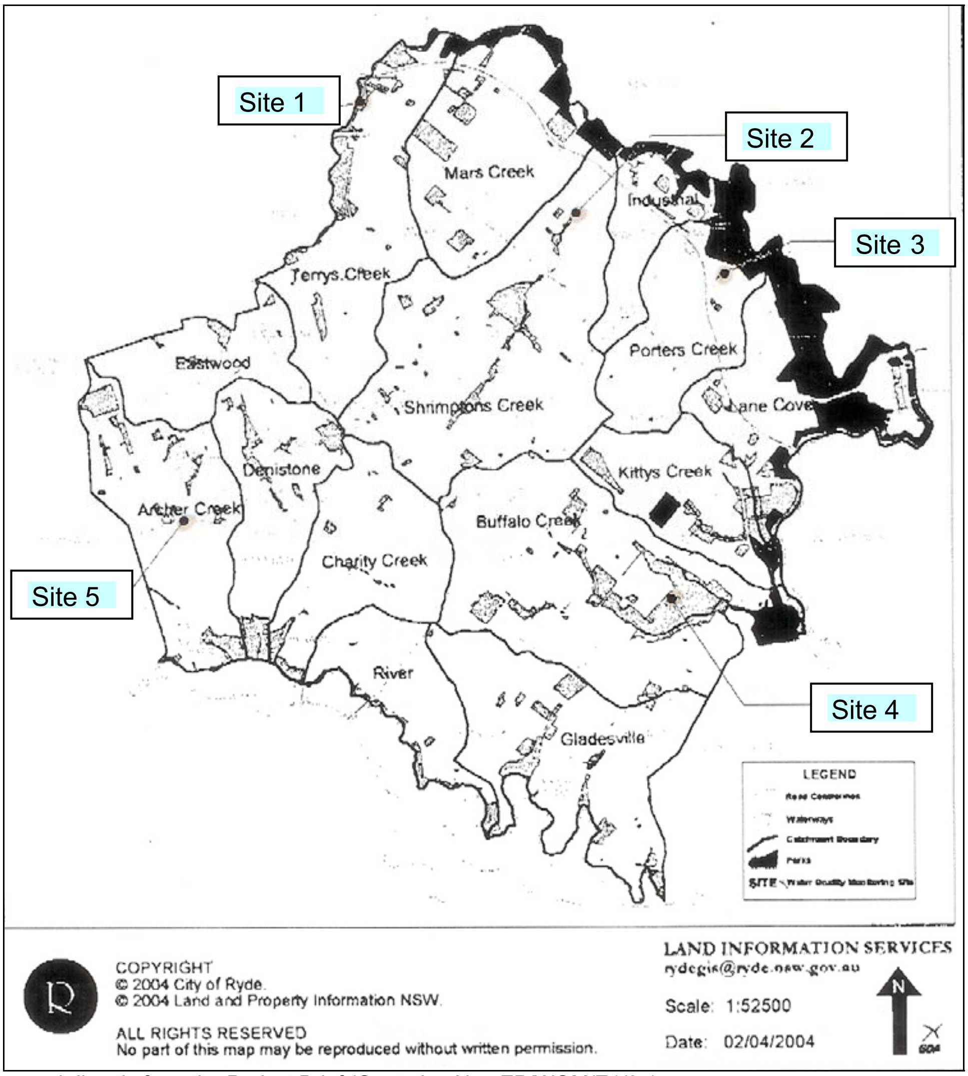
2 STUDY AREA

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 2 – Shrimptons Ck at Wilga Park,
- Site 3 – Porters Ck just before the stream becomes piped under the North Ryde Transfer Station,
- Site 4 – Buffalo Ck at Higginbotham Rd, and
- Site 5 – Archer Ck at Maze Park.

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).



Scanned directly 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, Spring 2004.

Site locations were slightly different for two of the water quality monitoring sites, in comparison to past sampling events:

- Site 3 - Porters Ck, and
- Site 4 - Buffalo Ck.

The Porters Ck sampling site was previously located immediately downstream of the pipe which flows under the North Ryde Transfer Station, however, the City of Ryde tender specifies sampling should occur in Porters Ck *before* it is piped underground. ECOWISE investigated and selected a site at the end of Wicks Rd approximately 250m upstream from the past sample site and upstream of the Transfer Station.

An access issue occurred with the Buffalo Ck site, where the site was described in the City of Ryde tender to be at the bottom of Higginbotham Rd. Higginbotham Rd is bordered by private property restricting access to the creek, therefore a site was located at the junction of Cressy Rd and Robinson Rd, approximately 200m upstream of the proposed past sample site.

Due to the close proximity of the new sites to the historic locations in addition to the fact that both new sites are not considered to differ greatly in habitat diversity or catchment influences, current and historic data should be comparable.

2.2 Spring 2004 Sampling Events

A total of three sampling events were conducted during the Spring 2004 monitoring program, with all sampling events separated by at least 4 weeks as required by the City of Ryde project brief (Quotation No: EP/WQM/E1/04):

- Event 1 – 14th and 15th September,
- Event 2 – 11th and 12th October, and
- Event 3 – 23rd and 24th November.

3 METHODS

3.1 Physical Habitat Description

Physical and in-stream habitat descriptions were conducted in accordance with the River Bioassessment Manual and 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, turbidity 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 QS requirements prior to deployment in the field.

Water quality data was evaluated using default trigger values for Aquatic Ecosystems of south-east Australian lowland rivers, and also 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).

Water samples were also 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.

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

Indicator	Units	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*
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 protocols defined in the "NSW Australian River Assessment System (AusRivAS) Sampling and Processing Manual, NSW EPA, July 2001" (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 Spring 2004 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 Spring 2004 sampling program

Site	Habitats present	
	Edge	Riffle
1	All events	November only
2	All events	N/P
3	All events	September only
4	All events	N/P
5	All events	N/P

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 collecting 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.

Figure 2: ECOWISE sampling edge habitat in Buffalo Ck during the September 2004 sampling event.

3.3.2 Riffle Sampling

The collection of the riffle habitat sample (fast shallow water over rocky substrate) involves placing the kick 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.

Figure 3: ECOWISE sampling riffle habitat in Porters Ck during the September 2004 sampling event.

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) do not reference the AusRivAS manual (Turak and Waddell, 2001).

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 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.

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.

<u>Univariate Analyses</u>

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. In some cases, higher values of this metric may indicate favourable conditions in terms of availability of food and/or the quality of habitat. However, 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 (<u>Aus</u>tralian <u>Riv</u>er <u>A</u>ssessment <u>S</u>ystem) 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.

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 Spring Edge and Riffle models are presented in Table 3 below.

Table 3: Variables required from each site to run the NSW Spring 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 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 Spring 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	1.16	1.18	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	0.83	0.8	Significantly impaired.	Fewer families than expected. Potential impact either on water quality or habitat quality or both resulting in loss of taxa.
Band C	0.51	0.43	Severely impaired.	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	0.19	0.06	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 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 most sensitive orders to environmental disturbance, and usually taxa belonging to these orders are the first to disappear (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) with the site index calculated 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 score ranges from 1 to 10, with the higher the score, the less impacted the site is from water pollution.

The interpretation of the 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

OE50SIGNAL2 = 5.0 / 6.1 = 0.82

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

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).

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 5% (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 in 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 if a significant difference was discovered between sites and samples, 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.

SIMPER cannot be run on a single group of results, and as this report outlines the first round of the strategies monitoring program and the objectives of this study are not to compare ecosystem health between sites but to provide baseline data for the long term evaluation of each creeks ecosystem health, SIMPER was not run on this data set.

4 RESULTS

4.1 Water Quality

4.1.1 *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 five core sites within the City of Ryde, Spring 2004. Results outside the ANZECC and ARMCANZ (2000) guidelines have been highlighted in red text.

Site	Sampling Event	Time sampled	Water Temp. (°C)	Conductivity (µS/cm)	pH	DO (mg/L)	DO (%sat.)	Turbidity (NTU)
*Aquatic Ecosystems			--	**125 - 2200**	**6.5 – 8.0**	--	**85 - 110**	**50**
^Primary Contact			**15-35**	--	**5.0 – 9.0**	--	**--**	--
1	September	13:30	**10.65**	203.1	6.84	5.08	**52.3**	2.4
	October	11:30	16.05	579	7.64	5.01	**51.1**	0.3
	November	10:30	15.50	227.7	6.70	6.90	**69.2**	2.6
2	September	10:30	**11.85**	280.7	6.83	2.20	**27.4**	3.1
	October	12:00	18.51	528.9	7.43	5.69	**55.9**	0.5
	November	08:00	17.04	241.6	**6.38**	2.93	**30.5**	11.5
3	September	15:30	18.45	**11,040**	7.16	5.29	**53.7**	2.1
	October	14:00	21.20	1,945	7.51	4.80	**54.1**	5.6
	November	14:00	18.97	1,244	6.90	7.44	**81.9**	0.4
4	September	13:30	**12.30**	863.9	6.99	5.36	**54.1**	38.0
	October	10:15	18.21	1,157	7.54	4.84	**50.3**	1.0
	November	11:30	16.97	976.8	6.50	5.80	**59.8**	6.1
5	September	11:00	**13.30**	269.3	7.01	6.53	**66.5**	0.6
	October	09:00	18.61	447.8	7.51	4.27	**45.8**	0.8
	November	09:30	17.16	491	6.55	8.02	**83.3**	4.7

* - 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 shows that dissolved oxygen concentrations regularly fall below recommended ANZECC and ARMCANZ guideline values across all sites for all sampling events. Other than for site 2, DO levels tend to improve in November over the previous two months.

Historically, DO levels have been lower than ANZECC and ARMCANZ (2000) Guidelines for Aquatic Ecosystems over a number of sampling events for 3 of the core sampling sites (Figure 4). Water quality results were not presented in the BioTrack reports to allow comparisons for Archer Ck and Shrimptons Ck.

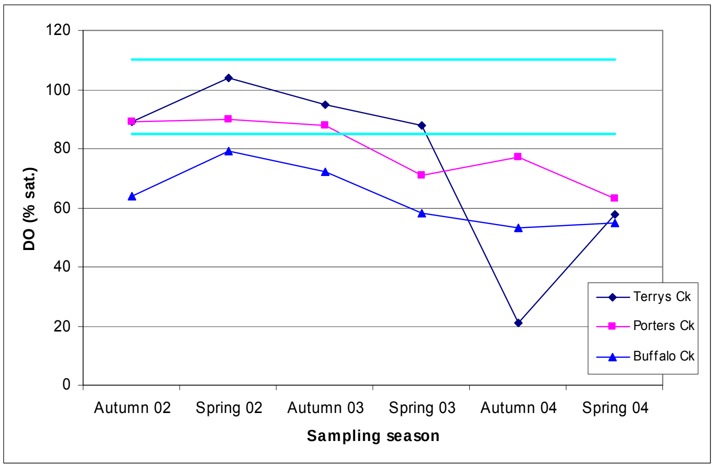


Figure 4: Historical Dissolved Oxygen (% saturation) results for 3 of the core monitoring sites measured by Robyn Tuft and Associates in Autumn 2002 to Autumn 2004, and ECOWISE in Spring 2004. For the purpose of this comparison, ECOWISE Spring 04 results have been averaged for the three events. The upper and lower ANZECC and ARMCANZ (2000) guidelines are represented by the light blue lines.

The other significant result was conductivity during the September 2004 event at Porters Ck (site 3) recording a level of 11,040μS/cm. Further investigation upstream of the sampling site found a point source discharge coming from a separate pipe inlet at Epping Rd. This discharge appeared to be contributing approximately 80% of the flow into Porters Ck (Figure 5) (visual estimate only). Robyn Tuft and Associates (2004) suggested that this discharge/runoff originated from the Epping-Chatswood railway construction site. *In situ* water quality checks at this discharge point and further upstream could not determine if the discharge was the cause of the inflated EC levels.

Figure 5: Discharge supplementing the flow in Porters Ck during the September 2004 event.

The Porters Creek site (site 3) was sampled on consecutive days in October 2004 and *in-situ* water quality measurements were taken on both days. On day 1 when macroinvertebrate samples were collected the drain in question was *not* flowing and EC was recorded at 1,945 μS/cm (Table 6). The following day the site was revisited again to collect water samples and the drain *was* flowing. EC values were recorded at 1,970 μS/cm (table 6) showing no appreciable difference from the previous days results.

Table 7: In situ water quality results from Porters Ck on two different days during the October sampling event, City of Ryde – Spring 2004. Results outside the ANZECC and ARMCANZ (2000) Guidelines for Aquatic Ecosystems are presented in Red.

Sampling Event	Time sampled	Water Temp. (°C)	Conductivity (µS/cm)	pH	DO (mg/L)	DO (%sat.)	Turbidity (NTU)
11th October	14:00	21.20	1,945	7.51	4.80	**54.1**	5.6
12th October	14:30	22.32	1,970	7.50	4.93	**56.7**	0.2

Further intensive investigation will be required to determine the source of the high EC water.

The riffle habitat sampled in Porters Ck (site 3) in September 2004 was flowing but was dry when visited in October and November. The flow in the riffle is dependent upon upstream point source discharges and appears to have no base flow generated from the catchment. It is recommended that no further sampling of this riffle habitat be undertaken as it does not represent a natural riffle habitat.

4.1.2 Laboratory Water Quality Results

The results for the laboratory analyses of water samples at each of the macroinvertebrate sites over the course of the program are presented in Table 8.

Table 8: Laboratory analysed water quality results from the five core sites within the City of Ryde, Spring 2004. Results outside ANZECC and ARMCANZ (2000) guidelines have been highlighted.

Site	Sampling Event	Time sampled	TDS (mg/L)	TP (µg/L)	Faecal Coliforms (orgs/100ml)	Total Alkalinity ($CaCO_3$)
*Aquatic Ecosystems			--	**50**	--	--
^Primary Contact			--	--	**150**	--
^Secondary Contact			--	--	**1000**	--
1	September	13:30	150	**110**	80	50
	October	11:30	310	30	44	64
	November	13:05	180	40	**150**	56
2	September	10:30	140	**90**	**880**	58
	October	13:45	260	**60**	110	76
	November	12:45	190	**90**	**1,000**	75
3	September	15:30	7,300	**170**	**12,000**	72
	October	14:30	1,100	30	**920**	24
	November	12:30	870	30	**17,000**	22
4	September	13:30	560	**80**	**400**	88
	October	09:00	600	40	**900**	100
	November	11:30	570	40	**230**	105
5	September	11:00	110	**150**	**650**	70
	October	14:00	230	50	**1,500**	82
	November	09:30	270	40	**1,700**	84

* - 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).

Total Phosphorus levels exceeded the Aquatic Ecosystem (ANZECC and ARMCANZ, 2000) guidelines at all sites during the September event, but Site 2 (Shrimptons Ck) was the only site where the levels remained above ANZECC and ARMCANZ (2000) guidelines for all three Spring events.

Faecal Coliform results were significant with Site 3 (Porters Ck) recording the two highest counts of 12,000 orgs/100ml in September and 17,000 orgs/100ml in November exceeding by a large margin recommended ANZECC and ARMCANZ (2000) primary and secondary recreational health guidelines. Archer Creek (site 5) also recorded high Faecal Coliform levels with the remaining sites at safe levels for secondary contact but not primary contact.

4.2 Macroinvertebrate Results

4.2.1 General Characteristics of Aquatic Macroinvertebrates

A total of 48 different families were recorded over the three Spring sampling events, with insects the most dominant (33 taxa) followed by gastropods (5 taxa), crustaceans (3 taxa) and bivalves (2 taxa). A full macroinvertebrate taxa list is presented in **Appendix A**.

4.2.2 Univariate Analyses

<u>Macroinvertebrate Taxa Richness</u>

Taxa richness for each of the macroinvertebrate sites over the three events is presented in Table 9.

The highest diversity was recorded from the Edge habitat at Site 5 (Archer Ck) with 25 taxa in October, followed by 20 taxa in November (site 5) along with Site 1 (Terrys Ck). Sites 5 and 1 also recorded the highest combined sample taxa diversity, with 29 and 28 taxa, respectively.

Porters Ck recorded the lowest diversity with only 10 different taxa collected over the course of the three sampling events in the edge habitat.

Table 9: Macroinvertebrate taxa richness from the five core sites within the City of Ryde, Spring 2004.

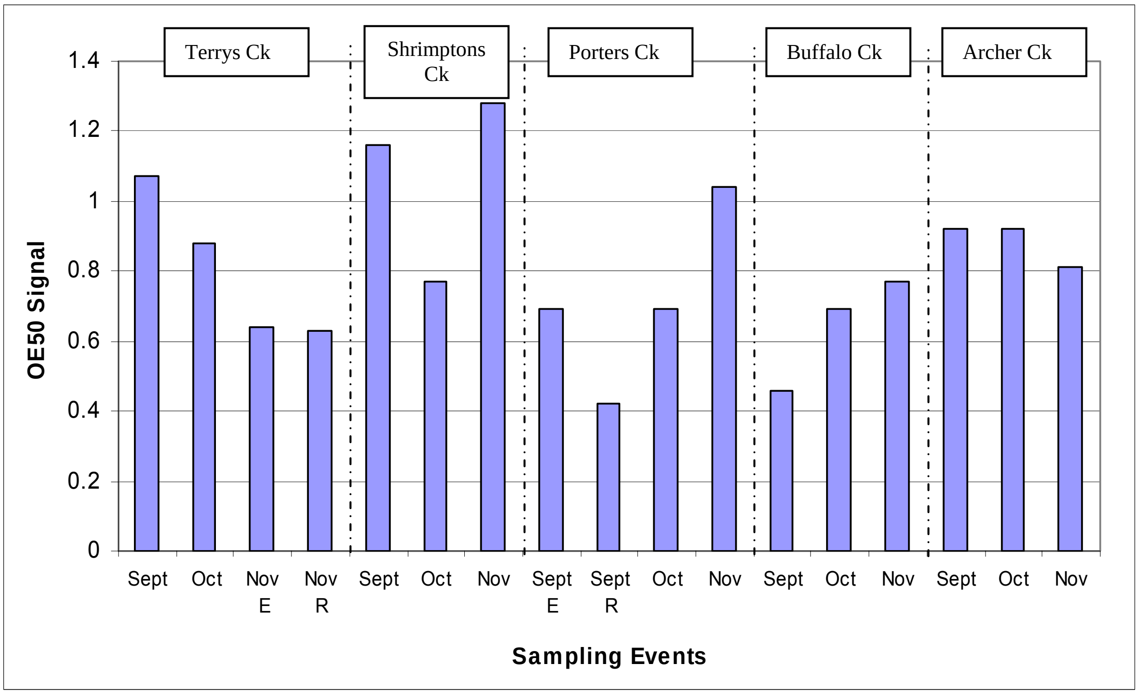
Site	Habitat	Sampling Event			Combined sample diversity
		Sept	Oct	Nov	
1	Edge	18	16	20	28
	Riffle	N/P	N/P	9	9
2	Edge	16	18	14	24
3	Edge	7	6	8	10
	Riffle	5	N/P	N/P	5
4	Edge	12	17	11	19
5	Edge	18	25	20	29

N/P – not present

SIGNAL2

SIGNAL2 Scores for each of the core sites over the three events are presented in Figure 6.

Although taxa diversity was highest at Terrys and Archer Cks, the highest SIGNAL2 scores were recorded from Shrimptons Ck during the September and November sampling events. Terrys and Archer Cks recorded a declining SIGNAL2 score over the three events, while in comparison, Porters and Buffalo Creeks recorded a gradual improvement.



Note: E – Edge; R - Riffle

Figure 6: OE50SIGNAL scores from the five core sites within the City of Ryde, Spring 2004.

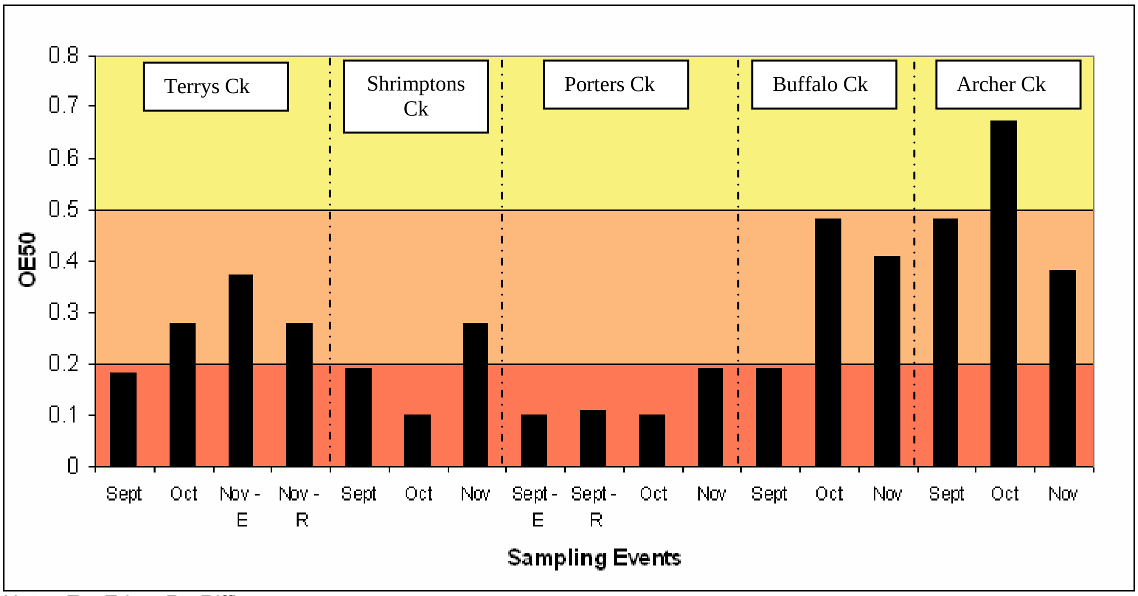
AusRivAS

Observed / Expected Ratios

AusRivAS results for each of the core sites over the three events are presented in Figure 7.

AusRivAS results for Porters Creek showed a similar trend with the SIGNAL2 and diversity results for this site during the three events, with the November event recording a higher taxa diversity, SIGNAL2 score and AusRivAS score. In comparison, Terrys Ck recorded a gradual improvement in AusRivAS scores over the three events while the SIGNAL2 scores depicting a gradual reduction in river health.

Archer Ck recorded the highest AusRivAS score during the October event which coincided with the site's highest taxa diversity. Buffalo Ck recorded the second highest AusRivAS scores during the October and November events.



Note: E – Edge; R - Riffle

Figure 7: AusRivAS results from the five core sites within the City of Ryde, Spring 2004. The AusRivAS bandings are also presented; D – Red, C – Orange, B – Yellow.

Overall, the AusRivAS results suggest all five creeks to be in a highly degraded state, with many fewer taxa present than expected.

Taxa Probabilities

The AusRivAS taxa probability results for the Spring 2004 program are presented in **Appendices B** and **C**. A total of 16 expected taxa were missing from samples collected over the Spring 2004 sampling event, with 3 of those missing within the PET taxa orders.

The PET taxa which had a >50% expected, included:

- Leptoceridae (6) – Trichoptera (caddisflies);
- Leptophlebiidae (8) – Ephemeroptera (mayflies); and
- Baetidae (5) – Ephemeroptera (mayflies).

Leptophlebiidae (8) were not collected in any of the samples and yet were considered to have an 89–100% probability of occurrence. In addition, Leptoceridae (6) is part of the Trichoptera order, and specimens were found in 1 sample each from Shrimptons and Archer Cks, however, there was an 81-90% probability of Leptoceridae occurring in all other samples. Baetidae (6) were expected in two of the samples collected from Terrys Ck, yet was only found in one sample from Archer Ck.

Other pollution sensitive expected yet absent taxa not part of the PET orders, included:

- Acarina (6) – mites;
- Scirtidae (6) – beetles; and
- Synlestidae (7) – damsel flies.

These three families ranged in their probabilities of occurrence, with Acarina (6) the highest at 91–93% expected to occur in those samples from which they were not collected (total of 8 samples from all sites excluding Archer Ck). Scirtidae (6) was also expected in all samples (53–70% probability), yet was only collected from 1 sample at Terrys Ck. Synlestidae (7) was expected in at least one sample from all sites with the exception of Site 2 (Shrimptons Ck).

The remaining 10 expected yet absent taxa with a >50% probability of occurrence, were generally pollution tolerant taxa.

The taxa collected during all three events at each site, and dominating the samples, are presented in Table 10. The dominant taxa across all sites were tolerant of pollution with SIGNAL2 scores of ≤3, included the Chironominae (biting midges), Oligochaeta (worms), and Physidae (snails).

Table 10: Taxa collected in all samples during all three events at each site, Spring 2004 City of Ryde.

Site 1	Site 2	Site 3	Site 4	Site 5
Chironominae	Chironominae	Chironominae	Chironominae	Chironominae
Oligochaeta	Oligochaeta	Oligochaeta	Oligochaeta	Oligochaeta
Physidae	Physidae	Physidae	Physidae	Physidae
Hemicorduliidae	Hemicorduliidae	Megapodagrionidae	Megapodagrionidae	Dugesiidae
Hydrobiidae	Ancylidae	Planorbidae	Notonectidae	Hemicorduliidae
Megapodagrionidae	Dugesiidae		Hemicorduliidae	Hydrobiidae
Coenagrionidae	Planorbidae		Hydrobiidae	Libellulidae
Dugesiidae	Sphaeriidae		Planorbidae	Acarina
Sphaeriidae				Coenagrionidae
				Tanypodinae

4.2.3 Multivariate Analyses

Classification and Ordination

Classification of the samples over the three events revealed most samples grouping together by sites at similarities >65% (Figure 8), with the exception of Site 1 (Terrys Ck). The Terrys Ck riffle sample separates at a low similarity to the remaining samples as would be expected, as biologically edge and riffle habitats contain different taxa. The remaining Terrys Ck samples are grouped in similarity with Site 4 (Buffalo Ck) and Site 2 (Shrimptons Ck). Of interest is the lack of separation of the Porters Ck riffle sample (309R) to all other edge samples. Sample 309R is very similar to in composition to the edge habitats collected from the same sites.

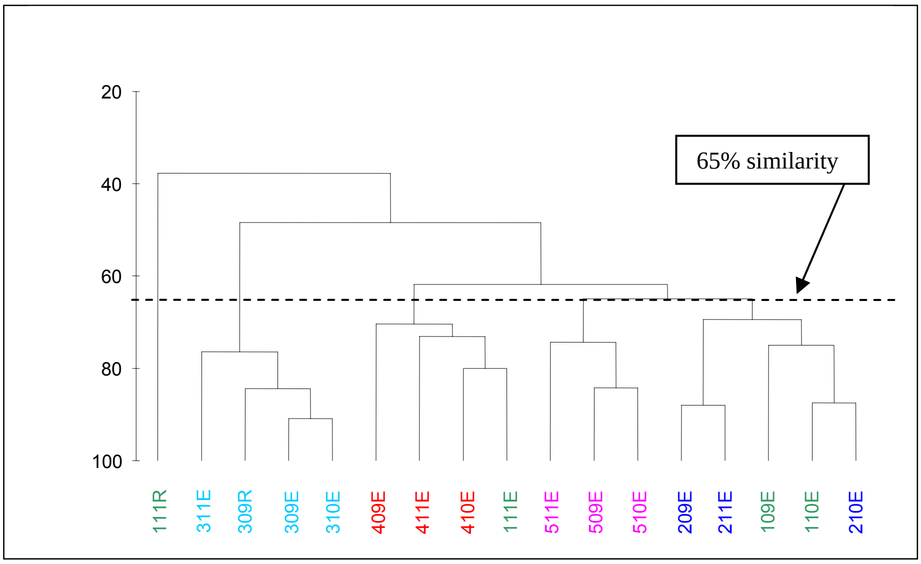


Figure 8: Classification of three macroinvertebrate samples collected from each of five core sites during the Spring 2004 monitoring program, City of Ryde. Site codes labelled with site number (eg. 1), sampling month (eg. 11) and habitat (E – edge or R – riffle). 65% similarity is indicated.

Although Site 1 samples are distinctly separated in the classification cluster, the ordination plot still presents the edge samples to be very similar within the ordination space (Figure 9).

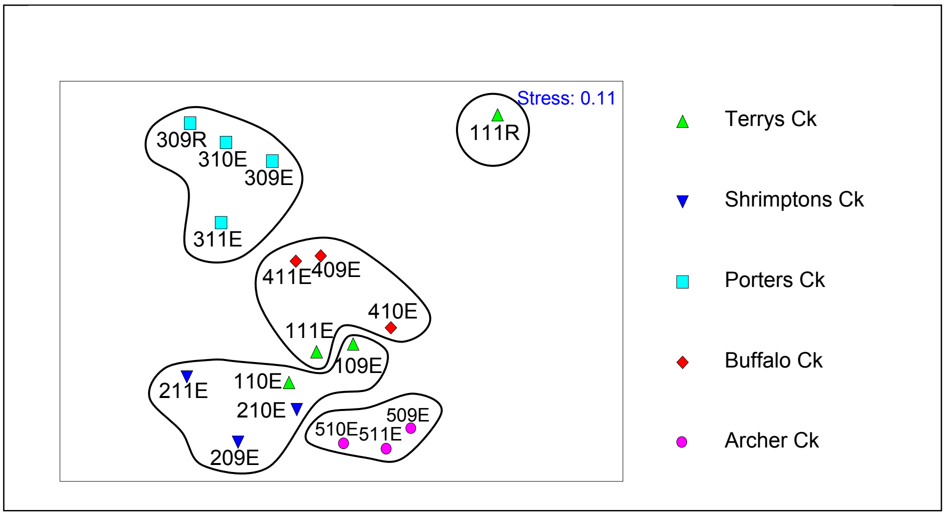
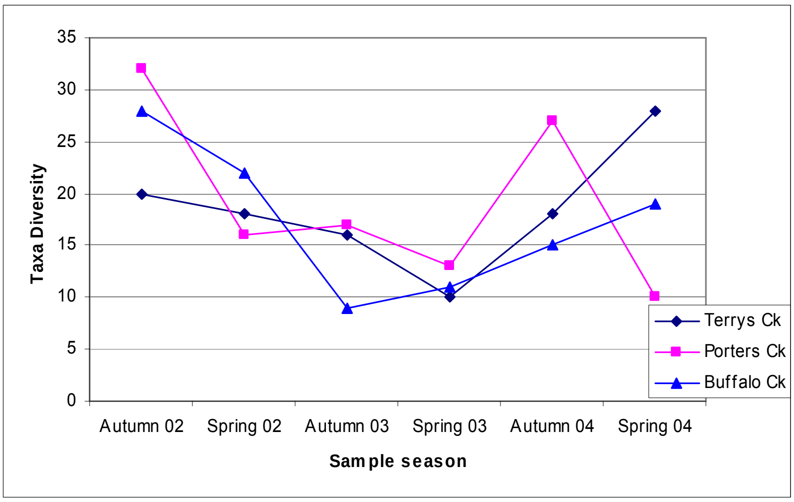


Figure 9: Multi-dimensional Scaling (NMDS) ordination of three macroinvertebrate samples collected from five sites during the Spring 2004 monitoring program, City of Ryde. Superimposed groupings refer to the 65% similarity level from the classification. (stress was calculated at 2 dimensions).

4.2.4 Comparison to Previous Monitoring Programs

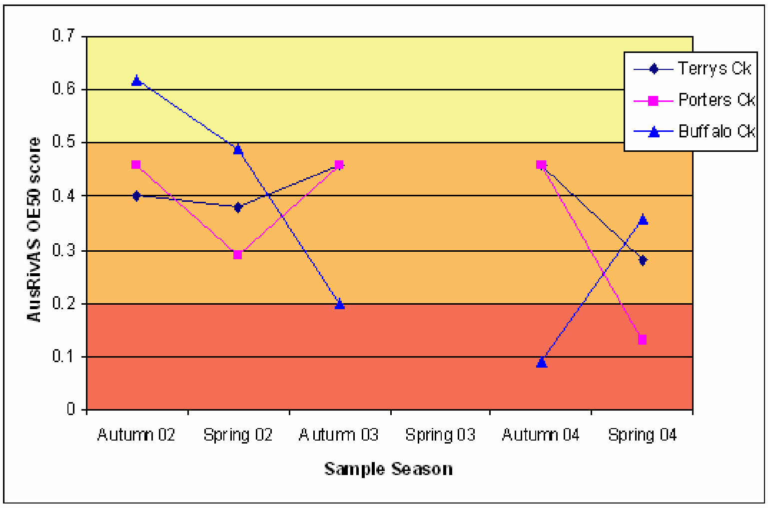
The limited information in each of the previous monitoring reports restricted the level of comparison possible with the current Spring 2004 data set.

Historical taxa diversity and AusRivAS OE50 results could be compared between those sites undertaken by Robyn Tuft and Associates (Terrys, Porters, and Buffalo Cks), although with some limitations (Figure 10 and Figure 11). The Robyn Tuft and Associates programs collected single samples during each season, compared with three events over thee months during the ECOWISE Spring 2004 program. For comparative purposes, the Spring 2004 data was combined for diversity, and averaged for the AusRivAS OE50 scores.



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

Figure 10:Taxa diversity for 3 of the core sites measured by Robyn Tuft and Associates in Autumn 2002 to Autumn 2004, and ECOWISE Spring 2004, City of Ryde. ECOWISE Spring 04 data was combined for the 3 events.



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

Figure 11:Comparison of AusRivAS OE50 scores for the core creeks sampled by Robyn Tuft and Associates in Autumn 2002 to Autumn 2004, and ECOWISE Spring 2004, City of Ryde. Spring 2003 data was not run through the AusRivAS model. ECOWISE Spring 04 AusRivAS OE50 data was averaged for the 3 events for this comparison. The AusRivAS bandings (Table 4) are also presented; D – Red, C – Orange, B –Yellow.

There appears to be no obvious temporal trends in either the taxa diversity results or the historical AusRivAS results. In Spring, Terrys Ck recorded the highest diversity compared to previous results, whilst Porters Ck recorded the lowest. Buffalo Ck results were in between. Terrys Ck samples all remained in band 'C', while Buffalo Ck recorded bandings in the 'B', 'C' and 'D' range over the three year period. Porters Ck declined from a 'C' banding to a 'D' banding in Spring 2004.

Similarities existed with dominant taxa collected by BioTrack in Archer Ck and Shrimptons Cks between June 2001 and May 2002, and those collected during the Spring 2004 event (Chironomidae, Oligochaeta and Physidae). There were 16 taxa similarities for Archer Ck (out of 29 ECOWISE taxa), and 13 taxa similarities for Shrimptons Ck (out of 24 ECOWISE taxa). Consequently, the results presented in BioTrack (2002) combine all samples collected monthly between June 2001 and May 2002 including the combination of results from edge and riffle habitats.

5 DISCUSSION

5.1 General Discussion

The results of the Spring 2004 sampling program indicate that the 5 core sites are typical of urban creeks with poor ecological health, dominated by pollution tolerant taxa and poor water quality including low dissolved oxygen. These results are comparable with past sampling events conducted by Robyn Tuft and Associates (2002; 2003a&b; 2004) and BioTrack (2001; 2002; 2004).

All sites were dominated by pollution tolerant taxa, including Chironomidae – biting midges (3), Oligochaetas – worms (2), and Physidae – snails (1), and lack many of the sensitive taxa present in high quality freshwaters. The results indicate that all sites are suffering environmental stress. 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 can all contribute to poor species diversity. Many Chironomidae species are tolerant to heavy metals and the dominance of Chironomids and Oligochaetas in a sample can also suggest organic enrichment (Yandora, 1998). Physidae are introduced snails indicative of poor water quality and nutrient enrichment (Gooderham and Tsyrlin, 2003).

Many expected taxa were found to be missing from the core sites which suggests the creeks are in a degraded state. The absence of these animals indicates poor water quality and poor in-stream habitat diversity. Ten of the 13 expected (but missing) taxa occurred from families with a generally low sensitivity to pollution (SIGNAL2 scores <5), however, the presence of several families of Odonates (dragonflies and damsel flies) in all samples at all sites suggests the creeks do have a limited capacity to support some larger predatory animals such as Megapodagrionidae (5) (Sites 1, 3 and 4), Hemicordulidae (5) (Sites 1, 2, 4 and 5), Libellulidae (4) (Site 5), and Coenagrionidae (2) (Sites 1, 5).

Low concentrations of dissolved oxygen can adversely affect many aquatic organisms that depend upon oxygen for their survival (ANZECC and ARMCANZ, 2000). Of the three core sites with available historical data (Terrys Ck, Porters Ck, and Buffalo Ck), the last three sampling events recorded all three sites with DO levels below recommended ANZECC and ARMCANZ guidelines (2000) (Robyn Tuft and Associates, 2004), with Terrys and Porters Cks recording particularly low dissolved oxygen values on several occasions (<6mg/L and <60% saturation). During the current study all sites on all sampling occasions failed to achieve recommended ANZECC and ARMCANZ guidelines for freshwater ecosystem protection.

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.

5.2 Individual Site Assessments

5.2.1 Terrys Ck

The Terrys Ck site contained a moderate diversity of macroinvertebrate fauna, with 28 different taxa collected over the 3 Spring sampling events from the edge habitat. There are a number of microhabitats within the reach including shallow and deep slow-flowing sections with some undercutting of banks and trailing bank vegetation, all providing quality habitat for macroinvertebrates. The Spring 2004 event collected the greatest diversity of macroinvertebrates but also recorded the lowest AusRivAS OE50 score with a 'C' banding.

The AusRivAS results classify the creek as severely impaired with 14 taxa having a >50% probability of occurrence but which were not collected from the creek during the Spring 2004 event. These expected taxa included the 6 indicator families all having a moderate to high sensitivity to pollution which explains the low OE50 score. Impacts which may be affecting the presence of these indicator taxa include low DO 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 Shrimptons Ck

Shrimptons Ck recorded 24 different taxa during the Spring 2004 sampling events, and resulted in the highest OE50 SIGNAL2 scores of >1 for two of the three events across all sites. Of the 24 taxa collected in Spring 2004, 13 taxa were also collected during the 2001/02 program including the three dominant pollution tolerant taxa, Chironomidae, Oligochaeta and Physidae.

Similarities occur at this site between current and historic sampling events. Ten of the 14 taxa expected by the Spring 2004 AusRivAS model to have a >50% chance of occurrence were not collected during any of the present or past sampling events. This result suggests that this site has been degraded for an extended period of time.

The AusRivAS results for the Spring 2004 event rated the site as between a banding 'D' (two events) and banding 'C' (one event) indicating extreme to severe impairment. Possible impacts causing the overall low ecological health for Shrimptons Ck include poor water quality (high TP and low DO) and toxicants in stormwater discharges.

5.2.3 Porters Ck

Porters Ck is a highly modified system, with the majority of the creek piped underground. It is not surprising, therefore, to find this site in very poor ecological health. The sampling site was located in a small section of Porters Ck that had a semi-natural channel from Epping Rd (adjacent to Wicks Rd) before being piped again under the North Ryde Transfer Station. The Creek also received a large volume of discharge from a pipe of unconfirmed origin.

This site recorded the lowest taxa diversity (10 taxa edge habitat) and AusRivAS OE50 scores of all 5 study sites, and also the lowest results for the same variables in comparison to previous events, however, the historical results show considerable fluctuations (Robyn Tuft and Associates, 2004). The majority of taxa collected were tolerant of pollution, with ≤3 SIGNAL2 Scores.

Porters Ck also recorded several water quality parameters exceeding the ANZECC and ARMCANZ (2000) guidelines for the Spring 2004 sampling event including DO, EC, Faecal Coliforms and TP. Poor water quality and lack of indicator taxa are major contributors to the low ecological health rating at this site, along with the limited natural habitat availability and fluctuating flows through the system.

5.2.4 Buffalo Ck

Buffalo Ck was classified as severely impaired with an upper level AusRivAS 'C' banding rating. There is evidence of high flows through this site with the presence of rubbish and debris in surrounding riparian vegetation above the normal flow mark, including a major log jam upstream of the site near the pedestrian bridge, restricting flows downstream (Figure 12).

Figure 12:Log jam in Buffalo Ck upstream of sampling site, near pedestrian walkway over creek.

Buffalo Ck showed some improvements in ecological health in Spring 2004, with increased diversity and AusRivAS OE50 scores when compared to Autumn 2003 results (Robyn Tuft and Associates, 2003a). A total of 19 taxa were collected over the three sampling events in Spring 2004, with taxa from a variety of SIGNAL2 scores including the common pollution tolerant Chironomidae (3) to pollution sensitive taxa such as Telephlebiidae (9). A number of microhabitats are present at this site including undercut banks and trailing bank vegetation, providing good habitat diversity for aquatic macroinvertebrates.

There were 11 expected taxa missing from the samples, and none of these indicator taxa were present in the Autumn 2004 and 2003 event, whilst only 2 were present in Spring 2003, and 4 in Autumn 2002. These results suggest many of the indicator taxa have not been present at this site for quite some time.

The major impacts on this creek include residential runoff, current clearing and poisoning of privet upstream of sampling site, and scouring flows (Robyn Tuft and Associates, 2004).

5.2.5 Archer Ck

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 (Figure 13). However, weeds are starting to invade the cleared banks and in-stream zones, and on-going maintenance may be necessary to prevent weeds spreading.

Figure 13:Archer Ck facing upstream to restoration works.

Archer Ck recorded the highest combined diversity (29 taxa) and the highest number of taxa present across all three sampling events (11 Taxa) during Spring 2004, when compared to the other 4 sites. Also, 16 of the taxa collected during Spring 2004 were also collected during the June 2001 – May 2002 program (BioTrack, 2002). 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.

Regardless of the highest diversity, Archer Ck still resulted in an average AusRivAS 'C' banding suggesting the site to be severely impaired. Only 4 of the 10 indicator taxa expected to have a >50% probability of occurrence in the Spring 2004 samples were collected during the 2001/02 program, suggesting many of the indicator taxa have not been present for some time.

5.3 Conclusion

All of the 5 core sites in the City of Ryde study are indicative of urban creeks with severe to extreme impairment and poor ecological health. The main influences on the creeks include poor water quality (exceeding recommended ANZECC and ARMCANZ, 2000 guidelines), and poor habitat diversity. The results and trends for biodiversity and ecosystem health obtained from the Spring 2004 sampling event are generally consistent with those obtained from earlier monitoring programs. These results would suggest that the 5 monitoring sites have neither improved nor deteriorated in health over this period.

The Spring 2004 sampling event 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 first 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 Spring 2004 sampling event it is recommended that :

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

- Routine maintenance on the restoration works upstream of the Archer Ck site at the Brush St end should be conducted due to the invasion of weed species into the riparian and in-stream zones of the creek,

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

- The current bi-annual water quality monitoring program be extended to include Nitrogen, and

- Relevant rainfall data be collected and used in the interpretation of the ecological data and to set an appropriate sampling timetable.

7 REFERENCES

ANZECC & ARMCANZ (2000). National Water Quality Management Strategy. Paper No. 4 Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 The Guidelines. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

BioTrack (2001). Biological Water Quality Monitoring of Shrimptons and Archer Creeks, Ryde. Prepared for Ryde City Council.

BioTrack (2002). Biological Water Quality Monitoring of Shrimptons and Archer Creeks, Ryde. Prepared for Ryde City Council.

BioTrack (2004). Post restoration macroinvertebrate sampling of Archer Creek, Ryde. Prepared for Ryde City Council.

Bray, J.R. and Curtis, C.T. (1957). An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* **27**: 325-349.

Chessman, B.C. (2003). New sensitivity grades for Australian River Macroinvertebrates. *Marine and Freshwater Ecology*. **54**: 95-103.

Clarke, KR & Gorley, R. N. (2001). Primer V5: User Manual/Tutorial. Plymouth Marine Laboratory, Plymouth.

Clarke, K.R. & Warwick, R.M. (2001). Change in Marine Communities: An Approach to Statistical Analysis and Interpretation: 2nd Edition. Plymouth Marine Laboratory, Plymouth.

Clifford, H.T. and Stephenson, W. (1975). 'An Introduction to Numerical Classification' Academic Press, New York.

Coysh, J., Nichols, S., Simpson, J., Norris, R., Barmuta, L., Chessman, B. and Blackman, P. (2000). AusRivAS National River Health Program Predictive Model Manual. http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/ (accessed March 2004).

EHMP (2004). Ecosystem Health Monitoring Program 2002-2003 Annual Technical Report. Moreton Bay Waterways and Catchments, Brisbane.

Gooderham, J. and Tsyrlin, E. (2003). The waterbug book: A guide to the freshwater Macroinvertebrates of Temperate Australia. CSIRO Publishing, Collingwood, VIC.

ISO. (1983). Water Quality: Methods of Biological Sampling - Handnet Sampling of Aquatic Benthic Macroinvertebrates. Draft ISO International Standard.

MRHI (1994). River Bioassessment Manual. National River Processes and Management Program. Monitoring River Health Initiative. Version 1.0. Commonwealth Environment Protection Authority, Canberra, A.C.T., Australia.

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.

Turak, E., & Waddell, N., (2001). New South Wales Australian River Assessment System (AusRivAS) Sampling and Processing Manual - 2004. Department of Environment and Conservation, NSW. (superseded by Turak *et al.*, 2004)

Turak, E., Waddell, N., & Johnstone, G. (2004). New South Wales Australian River Assessment System (AusRivAS) Sampling and Processing Manual - 2004. Department of Environment and Conservation, NSW.

Yandora, K. (1998) Rapid Bioassessment of Benthic Macroinvertebrates illustrates Water Quality in Small Order Streams in a North Carolina Piedmont City. Proceeeding from the 1998 NWQMC National Monitoring Conference. http://www.nwqmc.org/98proceedings/Papers/40-YAND.html (accessed August, 2004)

8 APPENDICES

Appendix A: Macroinvertebrate Results during the Spring 2004 Sampling Program

	Sample date	14 - 15 September 2004						11 - 12 October 2004					23 - 24 November 2004					
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck		Buffalo Ck	Archer Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck	Terrys Ck		Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck
	Site No.	1	2	3		4	5	1	2	3	4	5	1		2	3	4	5
	Habitat	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge
Order	Family																	
Acarina	Acarina		*				*					*			*	*	*	*
Bivalvia	Corbiculidae					*		*	*			*	*					*
	Sphaeriidae	*	*					*	*			*	*		*			
Coleoptera	Dytiscidae											*						
	Elmidae	*											*					
	Scirtidae	*																
Crustacea	Copepoda	*	*				*	*	*			*			*	*		
	Ostracoda		*			*	*	*	*			*			*			*
Decapoda	Atyidae											*	*					
Diptera	Ceratopogonidae		*															
	Psychodidae									*								
	s-f Chironominae	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	s-f Orthocladiinae	*					*				*		*	*				*
	s-f Tanypodinae						*	*			*	*	*					*
	Simuliidae													*				
	Stratiomyidae	*				*	*		*		*	*						
	Tipulidae						*					*		*				
Ephemeroptera	Baetidae																	*
Gastropoda	Ancylidae		*						*				*		*			
	Hydrobiidae	*		*		*	*	*	*		*	*	*	*		*	*	*

Appendix A cont'd: Macroinvertebrate Results during the Spring 2004 Sampling Program

	Sample date	14 - 15 September 2004						11 - 12 October 2004					23 - 24 November 2004					
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck		Buffalo Ck	Archer Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck	Terrys Ck		Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck
Ecowise Environmental	Site No.	1	2	3		4	5	1	2	3	4	5	1		2	3	4	5
	Habitat	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge
Order	**Family**																	
Gastropoda	Lymnaeidae	*																
	Physidae	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*
	Planorbidae		*	*	*	*		*	*	*	*		*		*	*	*	
Hemiptera	Belostomatidae	*																
	Corixidae								*						*			
	Gerridae							*										
	Naucoridae												*	*				
	Notonectidae					*					*		*				*	*
	Veliidae						*				*	*					*	
Hirudinea	Erpobdellidae				*													
	Glossiphoniidae											*						*
Isopoda	Oniscidae			*														
Nematoda			*									*						*
Odonata	Aeshnidae						*				*	*						
	Coenagrionidae	*	*				*	*	*		*	*	*				*	*
	Epiproctophora											*						
	Gomphidae	*	*															
	Hemicorduliidae	*	*			*	*	*	*		*	*	*		*		*	*
	Isostictidae												*					
	Lestidae														*			*
	Libellulidae						*		*			*						*
	Megapodagrionidae	*		*		*		*	*	*	*	*	*			*	*	

Appendix A cont'd: Macroinvertebrate Results during the Spring 2004 Sampling Program

	Sample date	14 - 15 September 2004						11 - 12 October 2004					23 - 24 November 2004					
	Site Name	Terrys Ck	Shrimptons Ck	Porters Ck		Buffalo Ck	Archer Ck	Terrys Ck	Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck	Terrys Ck		Shrimptons Ck	Porters Ck	Buffalo Ck	Archer Ck
Ecowise Environmental	Site No.	1	2	3		4	5	1	2	3	4	5	1		2	3	4	5
	Habitat	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Edge	Riffle	Edge	Edge	Edge	Edge
Order	**Family**																	
	Telephlebiidae					*					*							
Oligochaeta	Oligochaeta	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Trichoptera	Hydroptilidae		*				*	*	*									*
	Leptoceridae											*			*			
Turbellaria	Dugesiidae	*	*				*	*	*		*	*	*		*			*

Appendix B: QA Report

QA Report

For: City of Ryde Spring sampling program 2004
Project No.: QE000037

Site	Terrys Ck		Shrimptons Ck		Buffalo Ck	
Sample Date	Sep-04		Oct-04		Oct-04	
ID	Original	QA	Original	QA	Original	QA
Corbiculidae	1		4	3		
Sphaeriidae		1	3	4		
Copepoda			1	1		
Ostracoda	2	2	2	1		1
Ceratopogonidae						1
s-f Tanypodinae					1	1
s-f Orthocladiinae				1	1	
s-f Chironominae	11	11	11	11	7	8
Stratiomyidae	1	1	1	1	1	1
Ancylidae			1	1		
Hydrobiidae	3	3	1	1	5	5
Physidae	3	3	7	7	4	4
Planorbidae	3	3	3	3	3	3
Corixidae			3	3		
Veliidae					1	1
Notonectidae	1	1			5	5
Aeshnidae					1	1
Libellulidae			3	3		
Coenagrionidae			6	6	1	1
Telephlebiidae	1	1			1	1
Hemicorduliidae	1	1	4	4	2	2
Megapodagrionidae	8	9	2	2	8	8
Oligochaeta	2	1	6	6	6	6
Hydroptilidae			3	3		
Dugesiidae			4	4	1	1

identification error   counting error

	Terrys Ck	Shrimptons Ck	Buffalo Ck
Bray Curtis Similarity (%)	5.4	3.08	5.05

Pass or Fail **PASS** (avg. 4.51%)

Comments:
The bivalves Corbiculidae and Sphaeridae are extremely difficult to distinguish when individuals are minute.

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

Taxa observed and were >50% expected to be in the samples of the five core sites within the City of Ryde, Spring 2004. Taxa in bold have an individual SIGNAL2 score ≥6.

	Taxa	**Acarina**	Atyidae	Dytiscidae	**Scirtidae**	Tanypodinae	Chironominae	Veliidae	Gerridae	Notonectidae	**Leptoceridae**
	SIGNAL2	**6**	3	2	**6**	4	3	3	4	1	**6**
Site	**Sampling Event**										
1	Sept				0.53		0.65				
	Oct					0.81	0.65		0.62		
	Nov		0.53			0.81	0.64			0.69	
2	Sept	0.90					0.79				
	Oct						0.79				
	Nov	0.91					0.76				0.83
3	Sept						0.62				
	Oct						0.61				
	Nov	0.93					0.60				
4	Sept						0.60			0.73	
	Oct					0.80	0.60	0.87		0.73	
	Nov	0.93					0.63	0.87		0.69	
5	Sept	0.93				0.80	0.60	0.87			
	Oct	0.93		0.60		0.80	0.60	0.87			0.87
	Nov	0.93				0.80	0.61			0.72	

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

Taxa NOT observed but were >50% expected to be in the samples of the five core sites within the City of Ryde, Spring 2004. Taxa in bold have an individual SIGNAL2 score ≥6.

	Taxa	**Acarina**	Atyidae	Dytiscidae	Gyrinidae	Hydrophilidae	**Scirtidae**	Culicidae	Tanypodinae	Baetidae	**Leptophlebiidae**	Hydrometridae	Veliidae	Gerridae	Notonectidae	**Synlestidae**	**Leptoceridae**
	SIGNAL2	**6**	3	2	4	2	**6**	1	4	5	**8**	3	3	4	1	**7**	**6**
Site	**Sampling Event**																
1	Sept	0.91	0.57	0.65	0.86	0.83			0.81	0.52	0.98		0.85	0.62	0.68		0.9
	Oct	0.91	0.57	0.65	0.86	0.83	0.53			0.52	0.98		0.85		0.68		0.9
	Nov	0.92		0.64	0.87	0.84	0.54				0.99		0.86	0.61		0.5	0.88
2	Sept		0.6	0.83		0.84	0.7	0.65	0.86		0.89	0.58	0.88	0.57	0.5		0.81
	Oct	0.9	0.6	0.83		0.84	0.7	0.65	0.86		0.89	0.58	0.88	0.57	0.5		0.81
	Nov		0.59	0.79	0.55	0.84	0.66	0.6	0.85		0.91	0.5	0.88	0.58	0.54		
3	Sept	0.93		0.62	0.89	0.86	0.55		0.81		0.99		0.87	0.6	0.71	0.51	0.86
	Oct	0.93		0.61	0.91	0.87	0.54		0.8		0.99		0.87	0.6	0.72	0.52	0.86
	Nov			0.6	0.93	0.87	0.53		0.8		1		0.87	0.6	0.73	0.53	0.87
4	Sept	0.93		0.6	0.92	0.87	0.54		0.8		1		0.87	0.6		0.53	0.87
	Oct	0.93		0.6	0.92	0.87	0.54				1			0.6		0.53	0.87
	Nov			0.64	0.85	0.86	0.56		0.81		0.98			0.6			0.86
5	Sept			0.6	0.93	0.87	0.53				1			0.6	0.73	0.53	0.87
	Oct				0.93	0.87	0.53				1			0.6	0.73	0.53	
	Nov			0.61	0.91	0.87	0.54				0.99		0.87	0.6		0.52	0.86