River Health in the Fitzroy Catchment

Community Ownership

Natural Heritage Trust

Central Queensland University

Queensland Government
Department of Primary Industries

Queensland Government
Department of Natural Resources

SUMMARY REPORT

RIVER HEALTH IN THE FITZROY CATCHMENT

COMMUNITY OWNERSHIP

January 1997 – December 1999

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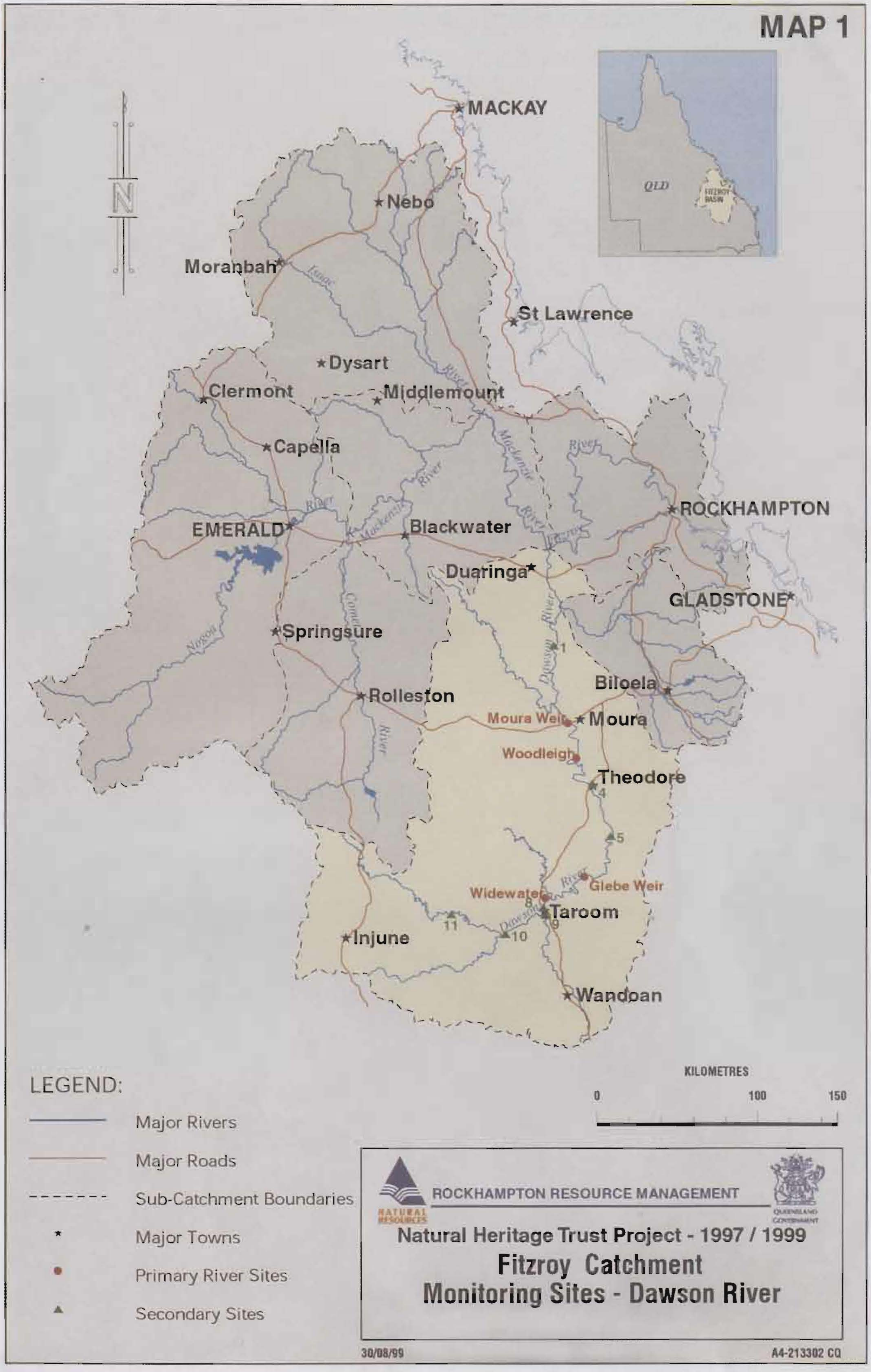
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* Primary River Sites.

EXECUTIVE SUMMARY

SUMMARY

The Fitzroy catchment in Central Queensland remains a large, semi-developed, sparsely populated region. This, the largest east coast Australian catchment, consists of several sub-basins including the Connors, Isaac, Nogoa, Mackenzie, Comet and Dawson. Rainfall and streamflows in the region are highly variable with the mean annual discharge of the Fitzroy River past Rockhampton into the southern lagoon of the Great Barrier Reef being about 5 million megalitres (ML). Grazing is the dominant land use in the catchment (80-85%), with dryland and irrigated cropping also extensive (6-10%). Coal mining, which occupies less than 1% of the area, makes a large contribution (approx. 60%) to the primary economic production for the region.

The aims of the current project carried out during 1997 to 1999 were to:

- better understand, through field studies, the water quality and river health issues for the Fitzroy basin identified in previous work
- work in collaboration with industry and community groups to understand the implications of the river health issues and be able to devise with them management strategies to improve river health

The collaboration with industry, Landcare, catchment, education and community groups took place throughout the entire Fitzroy region by use of a mobile van, focused on natural resource issues. Activities consisted of field days, Landcare meetings, in-school training, displays at industry exhibitions and rural shows and river health assessments on-site at various sampling locations.

Because of resource constraints, water quality and river ecology studies were carried out only in the Dawson sub-basin. This was not a serious limitation as most significant anthropogenic impacts on streams in the Fitzroy system are present in the Dawson as well as all of the major land uses in the region. Many of the environmental features of this sub-catchment were also found to be indicative of the Fitzroy River catchment in general.

River Health

During the study period, the annual rainfall was about average over most of the Fitzroy catchment, ranging from almost 1000mm in the northeast parts to 600-700mm in the Dawson sub-basin. Rainfall in August 1998 within the Dawson catchment resulted in a flow event down the length of the river. This flow was very much larger than the mean flow for that time of the year.

For the river health work, four Primary River Sites (two pairs of impounded and adjacent riverine sites) and seven additional Secondary River Sites were selected along the length of the Dawson River. These sites were sampled for a range of physico-chemical, chemical and biological parameters on a quarterly (winter, spring, summer and autumn) cycle for the Primary River Sites and on a more frequent basis for the Secondary River Sites in response to flows, seasonal agricultural factors or other temporal or spatial requirements for water quality assessments. For the water quality studies, parameters measured included: temperature, dissolved oxygen (DO), pH, turbidity and light, suspended solids (SPM), nutrients (nitrogen and phosphorus) and pesticide residues.

Results were interpreted against guidelines for fresh water quality in the draft ANZECC, 1999 document (Australian and New Zealand Guidelines for Fresh and Marine Water Quality).

Concentrations of many of the parameters were clearly outside the draft guidelines. Many DO concentrations were low, especially for the impounded sites. Of 109 surface water samples, 42 contained DO concentrations less than the guideline trigger levels. These low surface concentrations were invariably associated with even lower values at depth. Turbidity and SPM levels were much higher than the guideline values.

Median total nitrogen concentrations were at values between guideline levels for upland and lowland river types, while total phosphorus levels were all much higher than the guideline values.

Sampling of river water for pesticide residues was biased towards the summer cropping cycles (October to March) with 62% of samples taken in the summer periods when the bulk of pesticides are applied. Of 239 water samples, one or more pesticides were detected in 62 (26%) of the samples. Pesticide residues were more commonly found in summer. For example, 80% of the detections of the herbicide atrazine, the most commonly found pesticide, were made in the summer periods. In many instances concentrations exceeded guideline values when these were available. A number of pesticides commonly used in irrigated cotton production, including the insecticide endosulfan and the herbicides diuron, trifluralin, prometryn and fluometuron were also detected downstream from Theodore.

A total of 134 species of phytoplankton were identified during this study. This contained diatoms (20), chlorophytes (34), euglenophytes (44), dinoflagellates (5), chrysophytes (2), cryptophytes (2) and cyanoprokaryotes (27). The phytoplankton was dominated by cyanoprokaryotes at times when the phytoplankton cell concentrations were highest. A bloom of *Cylindrospermopsis raciborskii*, a known toxigenic species from this catchment, was detected in Moura Weir. Low cell concentrations were present at times of high sediment load and were dominated by eukaryotic algae. Samples of lowest cell concentration were often dominated by cryptophytes. Similar findings were obtained in an earlier study of various selected sites throughout the Fitzroy River catchment, reinforcing the applicability of findings from this data set to the river system as a whole.

A total of 86 macroinvertebrate taxa were recorded from the four Primary River Sites over the duration of the study. This is higher than the 70 taxa recorded during a previous study of the entire Fitzroy catchment from1993-96. Temporal variation in the total number of taxa per site was high and analysis of variance showed there were significant differences over time, though none of these was obviously related to season. Further analysis of this variation showed that only two of the more dramatic decreases in the number of taxa were statistically significant, both of which were associated with large variations in flow.
Analysis of variance of the taxon richness data and multiple comparison tests showed there was a significant difference between the impounded and riverine sites. Impounded sites were significantly lower in richness than their upstream riverine sites. Analysis showed there were no significant differences in the number of taxa between Glebe and Moura Weirs. A similar result was recorded when the riverine sites Widewater and Woodleigh were compared. Cluster analysis also clearly grouped the riverine and impounded sites separately.

Average invertebrate abundance ranged greatly over the duration of the study, from as low as nine to over 800 animals per sample. The impounded sites tended to have lower abundance than the riverine sites and numbers were generally lower during the first half of the study. Widewater (the most upstream site) had the highest macroinvertebtrate abundance on most occasions. The most abundant taxa were the Hemiptera (sucking bugs), Gastropoda (snails), Diptera (flies and mosquitoes) and Decapoda (crustaceans). Many of the fluctuations in abundance were due to large increases in the population of one taxon. Numbers of pollution-sensitive taxa (Ephemeroptera and Trichoptera) were generally lower at impounded versus riverine sites, though at least some of these taxa were present at all sites on all sampling occasions.

The two-year fisheries component of this project undertook work at the four Primary River Sites in the mid and upper sections of the Dawson sub-basin. Sampling was undertaken quarterly using a range of sampling methodologies. A total of 4024 fish were recorded from 19 species of 13 families, two of which were exotic. The results compared favourably with similar semi-arid catchments of sub-tropical Australia.

Species numbers declined further up the catchment in line with trends established in other Australian rivers. Fish species present in the catchment have evolved to cope with the ephemeral nature of the system, with many species responding to this cycle of drought and flood by opportunistic migration, spawning and rearing strategies. One species, bony bream, one of Australia's few herbivorous fish dominated gill net captures at all sites.

As part of the fisheries studies, a range of other relevant parameters were assessed including habitat type, physico-chemical water quality data and waterbody descriptions. This is the first comprehensive replicated fisheries sampling conducted in the Dawson sub-basin. The data compiled during the project is reflective of other baseline fisheries studies conducted within the Fitzroy catchment. .

Community Activities

Community activities were centred on the Fitzroy Catchment Trailer. This mobile regional resource was outfitted with facilities and resources to work with the community in increasing the level of knowledge, awareness and understanding of the range of important natural resource issues throughout the Fitzroy catchment. The Trailer was used as a focus for extending information and monitoring results to students, landholders, industry groups and Landcare members through displays and interactions at field days, conferences, workshops, regional shows and school visits. Throughout the project the Trailer was used to support Landcare groups, meetings and hands-on activities, interact with the Education system to support curriculum, Catchment Care, Saltwatch, Waterwatch, Pasturewatch and Junior Landcare programs and to promote the concept of integrated catchment management at urban and rural shows, rural trade exhibitions and local authority and community gatherings.

During the three years the Catchment trailer was operating, 4300 students throughout 55 schools in the Fitzroy Catchment and 28 urban/rural/trade shows, workshops, forums and conferences utilised the trailer and it's resources. Numbers of people passing through the display at the shows, conferences, workshops and forums can only be estimated. The three-dimensional model of the Fitzroy River catchment was a popular aspect of this display. At the completion of the project the Trailer was handed over to Landcare groups to continue the role in support of community groups working in natural resource management activities.

CONCLUSIONS AND RECOMMENDATIONS

This project has produced several major findings which although recorded for the Dawson River are also relevant to the total Fitzroy system:

- high levels of suspended solids and nutrients are common especially in the mid to lower Dawson. Long reaches of the river remain turbid for most of the time. The suspended material and nutrients impact on the freshwater ecosystem, the estuary and the offshore marine environment. Management strategies aimed at lowering the input of suspended solids and nutrients into rivers of the Fitzroy system should be accelerated. These would include improved riparian vegetation management on major and higher order streams for grazing and dryland farming areas, recycling of nutrient rich runoff from irrigated cropping lands and land disposal of treated waste water from urban areas
- low level residues of pesticides including insecticides and herbicides were commonly detected in waters of the Dawson especially from Taroom downstream in the mid Dawson. The herbicide Atrazine associated with summer grain crops was the most often found and a suite of pesticides used in irrigated cotton production was detected from Theodore downstream during the summer growing season. While the impacts of these chemicals on the stream biota are still not fully understood, management strategies through Best Management Practices, to minimise the movement of these pesticides offsite and into streams should be increasingly adopted. The strategies noted above for suspended solids and nutrients including improved riparian vegetation management, recycling of tailwaters and retention of soil in the paddock through improved stubble management are crucial components
- primary (algal) production was often low in the turbid waters of the Dawson even though available nutrient concentrations were high. The impounded waters were often characterised by low dissolved oxygen levels. When algal growth occurred, the phytoplankton was dominated by blue-green algae (cyanoprokaryotes) and the potential existed for toxic blooms to form especially in impounded waters. The impact of herbicide residues upon the microscopic plant life of waters of the region requires detailed investigation in future projects. Reduction in sediment levels is required to reduce nutrient inputs, enhance the growth of macrophytes which compete with harmful algae and oxygenate the water column
- macroinvertebrate populations at sites in impounded reaches had fewer taxa, appeared to be generally lower in abundance and tended to have lower numbers of pollution sensitive taxa than populations at riverine sites. More rapid and more extreme water level fluctuations may be a key factor as food sources and habitats are lost or altered. Submerged aquatic vegetation, an important habitat for macroinvertebrates, was not present at any of the sites studied - probably a result of water level fluctuations, high turbidity and possible herbicide contamination. Further research is required to isolate the effects of water level fluctuations and other factors such as pesticides on the macroinvertebrate communities and to understand the implications for the total aquatic ecosystem
- the fisheries study clearly identified the differences in the fish communities of weir and riverine sites in the Dawson sub-basin. It demonstrated seasonal trends in individual species with the data suggesting a need for concern over the future of several species. The direct and indirect impacts of catchment modification, current land uses, stream barriers, stream water quality and the potential impacts of further stream modification need investigation to establish long term trends in the complex fish communities.

individual species with the data suggesting a need for concern over the future of several species. The direct and indirect impacts of catchment modification, current land uses, stream barriers, stream water quality and the potential impacts of further stream modification need investigation to establish long term trends in the complex fish communities.

- the mobile resource centre (Fitzroy Catchment Trailer) was an effective tool in promoting education and community involvement in natural resource management awareness and issues throughout the region. The Trailer, with further refinement and development, should remain as a valuable tool for implementing environmental education in schools in central Queensland. The awareness and knowledge of the community about natural resource management issues is increasing significantly. Further development of effective partnerships between all levels of Government, research organisations, Industries and rural and urban communities should enable the ideal of sustainable natural resource management to be achieved.

This study together with others such as the State of the Rivers project for the Dawson River and major tributaries has shown parts of this river system to be moderately to heavily impacted by anthropogenic activities. With only one of the major sub-basins of the Fitzroy system not significantly altered by water infrastructure development and impacts apparent in the freshwater and marine environments, it may be time to seek management options that offer not only some remedial benefits for the impacted streams but also an economically and environmentally sustainable future for the whole of the Fitzroy catchment.

1. Project overview

INTRODUCTION

In the new millennium, the Fitzroy catchment in central Queensland remains a large, semi-developed, sparsely populated regional resource. The Fitzroy catchment is the largest of the eastern Australian catchments, consisting of several sub-basins including the Connors, Isaac, Nogoa, Mackenzie, Comet and Dawson. Mean annual discharge of the Fitzroy River past Rockhampton into the southern lagoon of the Great Barrier Reef is approximately 5 million megalitres (ML). The dominant land use in the region is grazing (80-85%), with dryland and irrigated cropping also extensive (6-10%). Coal mining, which occupies less than 1% of the catchment area, makes a large contribution (approx. 60%) to the Primary economic production for the region. The development of these industries during the last 150 years has been accompanied by significant changes to the vegetation cover and to the integrity of the ephemeral streams of the catchment. References to resource uses within the catchment, the physical environment, flora and fauna can be found in the Fitzroy Catchment Symposium Proceedings (Duivenvoorden *et al.* 1992)

Results of an assessment of "stream health" within the region (Noble *et al.* 1997) using a multidisciplinary, ecological, whole-of-catchment approach identified several issues related to observed river health:

- high concentrations of nutrients (nitrogen and phosphorus) in surface waters;
- high levels of suspended solids in the rivers, especially during flow events;
- a range of pesticides detected in the rivers, often temporally and spatially related to agricultural activities;
- sporadic but fairly common blooms of blue-green algae, especially in impoundments;
- decrease in the abundance and diversity of native fish due to the impact of barriers and changed flow conditions;
- large, rapid, imposed changes in stream heights, low concentrations of dissolved oxygen and other factors, especially within impounded water, detrimental to abundance and diversity of stream biota, including macroinvertebrates.

Discussions about these issues and changes in management practices that would help to minimise the impacts of land use have been held in many regional forums with a wide range of stakeholders including industry, Landcare and other community groups. This dialogue is an important part of the partnership between industries, Local Authorities and communities, State and Federal agencies and continues in many forms today.

Since this project, many activities that relate to natural resource management in the Fitzroy region have taken place at local, regional, State and Federal levels. Most of these studies now involve a close collaboration between researchers, industry and community groups. For the past eighteen months, the Fitzroy region has been the focus for a National Land and Water Resources Audit implementation project. This work has involved studies in three topics; Land Use Mapping, Social/Industry Capacity for Change and Ecosystem (including freshwater and estuarine systems) Health. Reports and general information from this work are available in hard copy or on the World Wide Web[1]. At the national level, the Fitzroy region has been targeted as a "focus" or management study area for the next few years for at least two Cooperative Research Centres (CRC's), the CRC for Catchment Hydrology and the CRC for Coastal Zone, Estuary & Waterway Management. These CRC's are groupings of research agencies drawn together for a period of time to tackle priority issues across a range of nationally important activities including economic production and resource management areas. Partners include Universities, State agencies and Federal agencies such as CSIRO. For the next couple of years, nutrient and algal studies will continue through CSIRO at sites on the Dawson River under the auspices of the National Eutrophication Management Program. Other on-ground activities with community groups, including work for this report are or have been supported through Natural Heritage Trust funding.

A Water Allocation and Management Planning (WAMP) process for the Fitzroy Basin has been undertaken recently by State agencies. The WAMP is an attempt to allocate water equitably on a basin wide scale for all users: industry, community and environment. The process has involved a community participatory aspect through the Community Advisory Panel, and has identified Key Research Areas for freshwater and estuarine systems of the Fitzroy. Several of these key research questions, including the implications of the Environmental Flow Objectives, are poorly understood and yet to be addressed.

State of the Rivers evaluations have been carried out for several of the Fitzroy sub-basins by State agencies. The assessments do not specifically include water quality parameters but have strongly highlighted the poor state of large portions of the riparian zone for many streams in the Fitzroy system and the potential impact on river health from impoundments. Recently within the region, the capacities of the Bedford and Bingegang weirs on the Mackenzie River have been increased and a new weir constructed on the Fitzroy at Eden Bann. Evaluation of proposals for large new water infrastructure developments by Government and commercial interests continues, including the Nathan Dam on the Dawson River. The Isaac/Connors and the upper Comet are now the only sub-basins in the region without sizeable dams or weirs.

At a regional level, many planning and natural resource management initiatives are currently in progress, utilising collaboration between community, academic, State and Federal agencies. The Fitzroy Basin Association Inc. has released a Central Queensland Strategy for Sustainability document. Water quality and river health are listed as important priorities within this and the related Dawson River Catchment Strategy document produced by the Dawson Catchment Coordinating Association Inc. State agencies such as the Queensland Department of Natural Resources (QDNR) have developed Strategic Plans for the region. In collaboration with State and Federal agencies, industries such as the cotton industry are moving towards adoption of Best Management Practices. There has been a clear need, identified by community/stakeholder groups, for a whole-of-government approach to regional natural

[1] http://www.nlwra.gov.au/

resource management issues and for a Regional Information Service, delivering information on natural resource management and other issues in a form readily assimilated by community stakeholders.

The aim of the 1997-1999 project was twofold and involved related activities in the Fitzroy region to:

- better understand, through field studies, the water quality and river health issues identified in the previous work (Noble *et al.* 1997) and elsewhere, and
- work in collaboration with industry and community groups to understand the implications of the river health issues and be able to devise management strategies to improve river health.

Ideally, the field studies would have involved sites in all of the sub-basins of the Fitzroy. Because of resource limitations, these studies were concentrated in the Dawson River sub-basin. This was not a serious limitation; the findings are relevant to the whole of the Fitzroy basin, as river health issues identified in the previous study (Noble *et al.* 1997) and elsewhere for the Fitzroy system were all present in the Dawson. The Dawson valley also supports all major land uses in the Fitzroy catchment (grazing, dryland and irrigated cropping, coal mining, forestry, national parks, rural and urban communities). The river has six weirs, so that long reaches (about 160 km) of impounded water are present and impacts are apparent. Finally, major water infrastructure development considerations are current for the Nathan Dam.

The collaboration with industry, Landcare, catchment, education and community groups took place throughout the Fitzroy region by use of a mobile Natural Resource Issues van. Activities consisted of field days, Landcare meetings, in-school training, stream-side river health assessments and displays at industry exhibitions and rural shows.

METHODOLOGY

Study Sites

Four Primary River Sites (two "pairs" of sites) were selected, each pair consisting of an impounded and adjacent riverine site. The upper Dawson pair comprised the riverine site at Wide Water and the adjacent impounded site at the Glebe Weir (sites 7 & 6 respectively, Map 1) and the mid Dawson pair consisted of the riverine site at Woodleigh and the adjacent impounded site at the Moura Weir (sites 3 & 2 respectively, Map 1). Seven additional Secondary River Sites were selected along the Dawson (sites 1,4,5,8-11, Map 1) including the upper Dawson site at Baroondah (site 11, Map 1) and the lower Dawson site at Baralaba (site 1, Map 1).

The Primary River Sites were sampled during 1997-99 on eight occasions, in an "after summer flows", "winter" and "before summer flows" cycle under low flow conditions. The Woodleigh and Moura Weir sites were additionally sampled more than 30 times in response to events significant for river health measurements. The Secondary River Sites were sampled selectively, some up to 20 times, in response to flows, seasonal agricultural factors or other temporal or spatial requirements for water quality assessments.

It is appropriate at this point to define terms applicable to the project. The river ecosystem refers to all freshwater areas of the catchment. Riverine refers to non-impounded water that may or may not be regulated by other flows. Impounded refers to sites located within in-stream storages.

Projects

The project was divided into six briefs, covering the major issues involved in the work, and including three stakeholder groups; QDNR, Queensland Department of Primary Industries (QDPI) and the Central Queensland University (CQU).

The Community Ownership brief (Chapter 2) aims were to promote community involvement and education through field days, Landcare meetings, in-school training, streamside river health assessments and displays at industry exhibitions and rural shows, focusing on natural resource issues.

The Rainfall and Streamflow brief (Chapter 3) detailed the seasonal variability in rainfall and runoff experienced in the Fitzroy basin, outlining contribution sources to flow variation and the effect of these on water quality processes.

The Physical and Chemical Water Quality brief (Chapter 4) was focused on the Dawson River. Ten quality parameters identified from a previous ecological assessment (Noble *et al.* 1997) were examined for the Dawson River. Results showed that many of these parameters were outside ANZECC guidelines.

The Phytoplankton brief (Chapter 5) analysed the relationship between phytoplankton and water quality in the Dawson River, highlighting the poor water quality and potential for toxic blooms. Guidelines for safe water usage and suggestions for improved water quality were presented.

The Macroinvertebrate brief (Chapter 6) used biological indicators, specifically macroinvertebrates, to monitor water quality in impounded sites in the Fitzroy Catchment. Results showed a significant decrease in water quality in impounded sites.

The Fish Communities brief (Chapter 7) related several water quality parameters to fish abundance and diversity in the Dawson River impounded and riverine environments, outlining seasonal trends in fish community composition and local extinctions due to man-made barriers.

These six briefs make up the Water Quality in the Fitzroy Catchment Project, supported by the Natural Heritage Trust. This summary report presents findings from projects undertaken 1997-1999 by individual groups within the project team.

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2. The Fitzroy Catchment Trailer & community activities

Catherine Collins[1].

SUMMARY

This extension work forms the community and educational component of the Natural Heritage Trust funded "Water Quality in the Fitzroy Catchment – Community Ownership" project. The activities and resources used throughout the project aimed to increase the knowledge, awareness and involvement of all levels of the community with regards to natural resource management issues in the Fitzroy catchment. A mobile Catchment Trailer was used as the focus for extending information and monitoring results to students, landholders, industry groups and Landcare members through displays at field days, conferences, workshops, regional shows and school visits.

During the three years the Catchment Trailer was operating, 4300 students throughout 55 schools in the Fitzroy Catchment and 28 urban/rural/trade shows, workshops, forums and conferences utilised the Trailer and it's resources. Numbers of people passing through the display at the shows, conferences, workshops and forums can only be estimated. The three-dimensional model of the Fitzroy River Catchment was a popular attraction to the display.

INTRODUCTION

The Fitzroy River Catchment, in Central Queensland, is one of the largest catchments on the east coast of Australia with important beef cattle, cropping industries and very significant coal production. The catchment area above Rockhampton is approximately 140 000 square kilometres in size, and accounts for almost 10% of the agriculturally productive land in Queensland. Map 1 shows the area covered by the Fitzroy River Catchment.

The National Landcare Program (NLP) funded project "Downstream Effects of Landuse" (November 1993 to December 1996) assessed the state of health of streams within the Fitzroy River Catchment using a multidisciplinary approach. Eleven primary river monitoring sites, at which stream flows were monitored, were chosen to represent the major sub-basins. This project collected baseline data on physical, chemical and biological parameters, information which provided a snapshot in time of the Fitzroy catchment.

The Natural Heritage Trust (NHT) funded project, "Water Quality in the Fitzroy Catchment – Community Ownership" followed on from the previous project and had a dual focus. One aspect was concerned with water quality monitoring along the Dawson River at four major sites and numerous secondary sites. The second focus involved using the Catchment Trailer as a mobile resource, increasing awareness and knowledge of natural resource issues in the Fitzroy River Catchment. The Catchment Trailer covered activities within the Fitzroy River Catchment while the monitoring

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[1] Department of Natural Resources, Biloela, 4715

activities were concentrated along the Dawson River. This chapter covers the activities of the Catchment Trailer and the results over three years.

Aims of the Community Extension Activities

The Catchment Trailer was developed as a major focus of the extension activities throughout the Fitzroy River Catchment. This mobile regional resource was outfitted with facilities to achieve a number of goals and objectives inline with Natural Heritage Trust funding requirements. The Catchment Trailer was used throughout the region to:

- Support Landcare groups, meetings and hands-on activities
- Interact with the Education system to support curriculum, Catchment Care, Saltwatch, Waterwatch, Pasturewatch (the "Watch" programs), and Junior Landcare programs
- Promote integrated catchment management approach at urban and rural shows, rural trade exhibitions, local authority/community gatherings and field days

The catchment Trailer successfully achieved all aims and objectives set out in the NHT project application. The results of activities and events detailed in this report show the extent of the catchment area that the Trailer covered during the three years of the project.

METHODS

The Catchment Trailer was developed for use by all schools, Landcare and Catchment groups, Government departments, and industry groups throughout the Fitzroy River Catchment. Figure 1 shows the area serviced by the Catchment Trailer and its resources. The activities of the Trailer were divided into two groups:

I. schools and education
II. adult extension activities

Education Activities

The introduction and increasing growth of Environmental Education material in Central Queensland schools has been a key element in the success of the Catchment Trailer and natural resource based activities. Landcare members, Waterwatch and Junior Landcare activities, and Environmental Education Centres throughout the Fitzroy Catchment utilised the Trailer's resources to support and add to current environmental education activities.

Both Primary and Secondary schools were approached to utilise the Trailer's resources to support and introduce the issues of water quality, catchments, land resource management, and environmental management. Information on the Trailer's capabilities was advertised at shows and field days, Environmental Education network meetings and staff meetings. The Environmental Education network was created by an NHT project in Rockhampton. Looking at informing Education officers on resources and material that could be incorporated into the existing curriculum or instigating changes to make the curriculum more locally and environmentally relevant to the students. Changes included learning about the Fitzroy River catchment and local land use activities in detail instead of learning about the River Nile and the activities that contributed to present day land resource issues. Many teachers felt the students would benefit from field trips to the Barrage in Rockhampton, catchment crawls, and water quality sampling activities. Field trips to overseas places were impossible on Department of Education, Queensland budgets and the students were benefiting from experiencing real natural resource management issues first hand and were being involved in processes to address these issues.

"Involve me and I'll understand" – Action Learning Processes

The Trailer was used as part of an action learning cycle being developed in conjunction with the Waterwatch project and Queensland Education officers. The Catchment Trailer would introduce the concept of a catchment to the students. The Waterwatch project would look at the river system as a living environment, linking land use activities with stream health and macroinvertebrates. The teachers and Environmental Education centres providing further information, links and planning to build the activities into a teaching module.

The structured catchment awareness session included hands-on activities, a short video on the statistics of the Fitzroy catchment and a question and answer period. Most sessions were approximately 45 minutes in length to accommodate a teaching session. This was designed so that the Trailer could be utilised by an entire school for their curriculum requirements within one school day.

After the in-classroom session, students made their way outside to participate in the interactive activity and also to view the model of the catchment housed inside the Trailer. The following is an example of the session plan for an upper primary school visit:

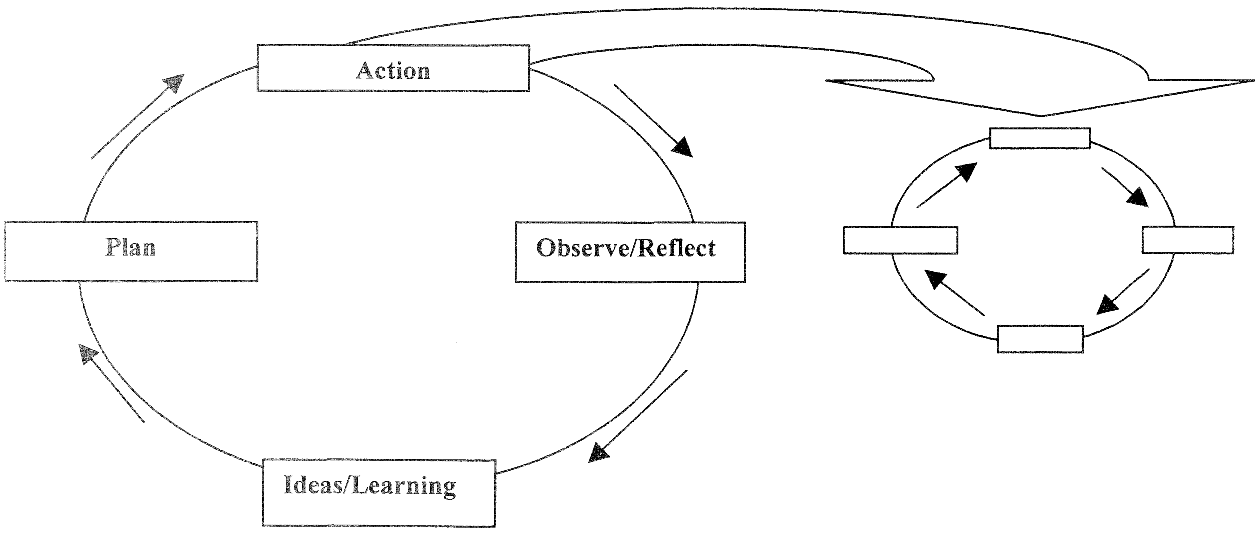
- Welcome and brief introduction to the purpose of the session
- Questions to class on their knowledge of catchments – brief description of our Fitzroy River Catchment (towns and centres included in boundary)
- Brief explanation of the video, watching of the video and questions about the content (size of catchment, 'Is the Fitzroy catchment bigger or smaller than England?', land resource issues discussed)
- Conduct hands-on activity. (activity type depending on curriculum and knowledge of class, "River Story", "Water of the World", "Water Cycle")
- Reflect on the message being delivered in the activity and apply to the Fitzroy situation
- View the catchment model and displayed posters in the Trailer
- Answer any questions from teachers and students

The Waterwatch component followed up with information for students on their location and impact on water quality and stream health in the catchment. The students participate in activities such as catchment crawls (travelling through their immediate catchment area investigating land uses, natural resources and stream health issues), water quality testing, searching for macroinvertebrates in the local stream or waterway and making a small scale of their own catchment using local knowledge.

The action learning cycle (Fig. 2.1) provided a useful tool in introducing the concept of a catchment to the students and also useful for me when planning and reviewing the session or introducing a new activity. The session introducing the concept of a catchment, watching a new video explaining the features of the catchment, doing an activity to reinforce the management issues, impacts of land use on water quality and the idea we all live in a catchment and are responsible for all impacts. The action learning cycle follows the processes of introducing a new piece of information, providing visual support, doing activities to reinforce the information aiding in better understanding, then the question and answer period to fill in any gaps, or to further the concept. Activities and resources left with the teachers allow follow-up activities and learning. The Waterwatch and subsequent Environmental Education activities build on the new information creating a broader information base, personal experience and understanding of how they fit in to the catchment. Hence, the action learning cycle keeps cycling.

The sessions were designed to provide real information on the catchment, be relevant to everyone that lives in the Fitzroy River Catchment and interesting to students and adults.

Figure 2.1: Action Learning cycle



Resources

When conducting the sessions with students, the resources required to deliver the information varied with the situation. Sessions with one class or year level at a time were often based in a large, open classroom with a television and video, the Catchment Trailer usually parked on the oval or manoeuvred close to the buildings in the shade. Sessions conducted as part of an environmental theme day were shorter, sometimes without a television and video but concentrating more on interactive activities with varied age groups, numbers of students and diverse local knowledge

2. The three-dimensional model of the Fitzroy Catchment housed in the Trailer
3. An A4 map of the Fitzroy Catchment that the students each receive
4. Hands-on activities of various types and age levels

Fitzroy River Catchment Video

The video used in the longer sessions was developed during Beef 97. Its purpose was to deliver information on the grazing and agricultural industries throughout the region to visitors and guests during their stay in Rockhampton for the week long Beef Expo. It covered topics on water, weeds, soils and vegetation management in the region and some of the relevant issues and how the community, industry and Government departments were addressing these issues. The video was used for the three years of the project because it had local relevance and local images so that students and community members watching the video could relate to places where they live, work and carry out recreational activities.

Three-Dimensional Model of the Fitzroy Catchment

The three-dimensional model (Fig. 2.2) housed inside the Trailer showed the catchment area from an aerial perspective, including mountain/upland areas, rivers and streams, towns and vast agricultural areas. Not all towns and streams were named, however visits to the smaller schools allowed them to identify their area by applying local knowledge. More labels were developed and a greater sense of ownership by the students and teachers was founded.

Figure 2.2: 3-Dimensional model of the Fitzroy River Catchment

Map of the Catchment

An A4 size map of the catchment was also distributed to all students showing the major rivers and streams, the sub-catchment boundaries, major towns and the system of roads and major highways that dissect the Fitzroy catchment. This helped when

Map of the Catchment

An A4 size map of the catchment was also distributed to all students showing the major rivers and streams, the sub-catchment boundaries, major towns and the system of roads and major highways that dissect the Fitzroy catchment. This helped when referring to the size and location of the catchment, direction of the river flows and different towns. Many of which students have visited, know relatives that live there or have lived there themselves.

Hands-on Activities

The activities used with the different year levels and classroom situations are listed as appendices. This list outlines the activities and describes what was involved, the outcomes of the activities and how they related to the Fitzroy Catchment.

The Story of a River activity encourages students to explore the links between land use impacts and water quality. It discusses the concept that all of us living within catchments contribute directly or indirectly, significantly or not so significantly to the degradation of our river systems, often without realising the relationships river and human or the impact of human activity. The procedure is to start with a bowl of clear water and pour in additives representing substances that come from the identified land uses. Film canisters are filled with the corresponding non-toxic substance, and not opened until that land use is mentioned in the story. The canisters are then emptied into the bowl of water (which represents the river). After the 16 land use canisters identified in the story are emptied into the river, the river flows out to sea along with the mix of substances. The students are then asked what measures can be taken to prevent the occurrence of the river flowing out to sea in such a state. The students are then asked what they can do to prevent their river/local creek from becoming like the one in the story. Some of the land uses and their non-toxic substances more commonly identified by the students are identified in Table 2.1.

Table 2.1: The Story of a River, some land uses and associated substances depicting pollutants and waste products

Land use	Substance
Herd of cattle	Thick muddy water
Grazing land	Salty water
Coal mine	Vinegar (acid run-off)
Industry	Soapy water (detergent)
Water skiing	Oil
Park litter	Plastic, Styrofoam, etc

Whizzy's Incredible Journey was an adventure story used for the younger year levels (Years 1 – 3). The story followed a watery character called Whizzy the Water Drop who travels around three different water cycles, the river journey, the tree journey and the underground journey. The river journey was adapted to fit the Fitzroy situation by Whizzy always flowing to the Fitzroy River from where ever he fell from the sky and always flowing out to the sea through Port Alma. The stories always ended up with Whizzy flowing out to the sea and being evaporated from the sea near Keppel Island.

Water of the World activity was conducted with the higher year levels. It investigates the availability of water for human use. Why should students be concerned about water? After all 70% of the Earth's surface is covered by water. Water can be found almost everywhere on earth – in the soil, rivers, oceans, lakes/dams, underground, even in the atmosphere, but how much is actually clean enough and available for our use? The activity outlines water usage, where we can be more efficient and how much water it takes to conduct everyday activities around the home and school. This activity is usually done when the students have already seen the Trailer and the water quality issue is relevant to their studies.

The Water Cycle in a Cup visually demonstrates to the students the various stages of evaporation, transpiration and condensation. Each of the students are given a clear plastic cup with 50ml of lukewarm water, asked to cover it with plastic cling wrap and place it in the sun. The students then observe the water cycle during the day to see the changes occurring. They then fill out an activity sheet explaining the changes and answering questions on the behaviour of the water. This activity was good with small classes, a follow-up to Whizzy the Water Cycle story and helpful to show that water is a finite resource and just keeps getting recycled in the environment.

These activities were aimed to be both fun and informative. If students are enjoying an activity, they will become involved, input their own experiences and knowledge, possibly leaving with more information or ideas.

Adult Community Activities

The Catchment Trailer was also utilised for workshops, rural and regional shows and field days. The method followed was different from the one used for educational activities. Landcare and Catchment groups were keen to display projects, show information videos, and demonstrate new land resource management strategies and new technology.

The atmosphere of the display was critical to get people to come into the annexe and have a look at what was displayed. Most people are hesitant to enter a situation that makes them feel uncomfortable or where they are uncertain of what will happen. Most Landcare and Catchment members encouraged a friendly non-threatening environment, encouraging people to seek information, ask questions and take information and knowledge away from the display. There was always something for everyone, whether it was stickers for the children, business cards for contact details for further information, weed brochures, or meeting someone they had been talking to on the phone about an issue.

Locations

The Catchment Trailer covered a number of regional and rural shows, field days, workshops and conferences throughout the Fitzroy Catchment. Many shows were attended more than once. The shows in Central Queensland follow a tight time schedule. The shows start in early April and finish in mid June. Most of the shows are well patronised by Landcare and Catchment groups to display their projects, encourage interest from the general community and obtain feedback on project progress and relevance to their area.

Methods of encouraging interest in the display included showing videos, bright colourful posters on topical issues, balloons, stickers, free material to take home and read, the opportunity to have questions answered.

Resources

The Trailer provided groups with a covered annexe, television and video player, display boards, folding tables, chairs, extension cords, lighting and a three-dimensional model to graphically depict project coverage or weed infestations in certain areas. These resources were free to groups wanting to develop displays for regional and rural shows. The power source allowed an urn and eskies to be housed in the Trailer to provide people with a cuppa while they wandered around the display.

There were a number of different land resource management issues displayed within the Catchment Trailer. Department of Natural Resources Pest Facts, Water and River Facts, posters on the Fitzroy River Catchment (both two dimensional and a satellite map), brochures on fisheries outcomes and results of sampling activities, Landcare brochures, blue-green algae identification posters, Parthenium weed posters to give away and potted or pressed weed samples of local significance.

The Trailer provided a background to target various locally relevant issues, a map to locate these activities or issues, and a point of interest to attract the attention of adults and children to find out what the display was all about. The groups always had an outside site (due to the size of the Trailer), which provided the ability to offer a walk-by display, no commitment required by the community, only the chance to look and learn something new or interesting about the area in which they live.

Results

Education Activities

During the three years the Catchment Trailer was operating, schools in five Education Districts in Central Queensland were visited. Gladstone, Mackay Hinterland, Rockhampton, Emerald and Chinchilla Education districts cover the Fitzroy River catchment and most schools within these districts were included in either school visits, combined theme days or combined small camps. The following 5 figures show the schools located in each of the districts.

The education districts are based on Queensland Education boundaries and do not follow any catchment areas or land resource management boundaries. This proved to be a challenge with the schools located in the upper parts of the Dawson River Catchment (the southern part of the region). The major towns of Miles, Chinchilla, and Toowoomba service these schools. Many families drive to Toowoomba for health and medical services, shopping and leisure activities. Rockhampton, Biloela and Gladstone were seen to be out of the way and not a feasible option when requiring services and facilities. This gave the students and teachers the impression that the Dawson River in this area flowed to Toowoomba, the same direction they drove to access needed services and resources. Many trips to these schools, the use of maps and field trips to the Dawson River slowly identified the true direction of river flow and created a sense of belonging within the greater Fitzroy Catchment.

Table 2.2 summarises the schools, student numbers and area covered by the Trailer during the three years of the project. A complete listing of schools visited is presented in Table 1, Appendix C.

Table 2.2: Student numbers from each education district visited by the Catchment Trailer 1997-1999

Education district	Number of schools visited	Student numbers
Chinchilla	5	256
Emerald	9	500
Gladstone	9	320
Mackay hinterland	4	85
Rockhampton	30	697

Final numbers for many of the schools were absorbed by the activities conducted in relation to the Year Five Days. This is an annual event organised by officers from the Department of Primary Industries (DPI), Department of Natural Resources (DNR), Department of Environment (DOE), and Queensland Education and conducted at the Rockhampton DPI office in early June. Year Five students from all Rockhampton district and nearby schools are invited to attend a day of interactive learning. Many topics covered on the day include water quality and catchments, animals (cows, chickens and other farmyard animals), freshwater fisheries and ocean creatures, sun safety, cotton industry information plus many more. During the three years the Catchment Trailer attended these activities, approximately 2600 students were involved with the activities focusing on catchment awareness and water quality in the Fitzroy Catchment. Each of the interactive sessions were twenty (20) minutes in length, four sessions in the morning, four in the afternoon, and students numbers averaged 100 per session. This required assistance from other Landcare and Waterwatch members to help conduct the sessions. Environmental Education packages were handed to all teachers to further information and knowledge raised during the catchment and water quality sessions.

Adult Community Activities

The Trailer was booked for 34 functions throughout the Fitzroy Catchment region. This included requests from Landcare groups, officers of Department of Primary Industries and Natural Resources, local Councils, Industry bodies, Catchment groups and Environmental Education Centres. Table C.2 (Appendix C) outlines the workshops, field days, conferences and rural and regional shows the Catchment Trailer attended.

The attempt to attend most regional and rural shows at least once was achieved during the project. Many of the smaller shows such as Wowan and Capella had limited opportunity to set up displays. These shows are mainly a community fair with agricultural, culinary and craft competitions rather than trade and industry displays. They are smaller shows with very limited outside involvement, with the activities and competitions patronised by the immediate community members.

Many of the shows overlapped with their dates and duration making it difficult to attend the Capella Show (Friday and Saturday) and still attend the Wowan Show (Saturday and Sunday). The shows fell mainly early in the week or at the end of the week, usually finishing on a Saturday. The show circuits that operated split in two when they reached Central Queensland. One circuit moves towards the Central Highlands/Alpha districts before heading towards to Mackay, the other circuit concentrates on the eastern districts (Theodore, Baralaba, Biloela) before finishing in Rockhampton and Gladstone. The show circuit involves the events such as sideshow alley, pottery, food outlets, product peddlers, and the rodeo riders. The information gathered by these show regulars was invaluable as to which shows were best supported by their local communities and which shows were struggling to attract interest by locals. In 1997, local community better supported the Clermont Show than the Emerald Show. This was obvious with the numbers of people that passed through the display, the amount of brochure information given out, and the number of enquiries regarding land resource management issues. The local Landcare group in Clermont also noticed an increased number of people asking about local projects, a need to source more give away material from Emerald DNR office, and a large percentage of their members offering to help at the display.

The support and utilisation of the Catchment Trailer and its resources by many of the different groups and industry bodies throughout the catchment is reflected in the following table. Many of the resources that the Trailer provided when borrowed by the groups are the items necessary for setting up a display. The annexe, television and video, display boards, fold chairs and tables are resources that can be difficult for a group to access during the show period. Many of the groups would historically approach chemical companies, local agricultural agents or industry groups for the use of their marques and tents. If the businesses were already utilising their equipment for their own displays, the Landcare group would try elsewhere. The Catchment Trailer provided the group with all the display resources they required without having to organise anything more than their posters, brochures, the site, electricity and smoko items.

Discussion

Education Activities

The Catchment Trailer was a resource well suited to increasing interest, awareness and information on the Fitzroy River Catchment in the schools in Central Queensland. The three dimensional model, the catchment video, interactive activities and the approach used to involve the students all created an interesting, and enjoyable learning situation for students. The information was based on a specific area and experiences that the students were able to relate to personally and could understand where they were placed in the big catchment picture.

Saltwatch, Pasturewatch, Waterwatch and Junior Landcare activities expanded on the introductory activities delivered by the Catchment Trailer session to look at other natural resource management issues. Environmental education activities were well supported by the catchment Trailer and the impact on the science curriculum over the three years the Trailer was operating was very positive. The Biloela State High School has incorporated water quality monitoring activities into their Year 9 science activities in Semester One. This is managed into the subject of the food chains and life cycles. They conduct water quality monitoring activities, look for macroinvertebrates, observe any evidence of animals and define their eating preferences and analyse how all the creatures coexist. Since the completion of the Water Quality Fitzroy project, the Callide Valley Landcare group have successfully acquired funds to purchase Waterwatch water quality testing equipment which can be borrowed by the Year 9 students to use for their field activities. This equipment is available for all nine schools in the Callide Valley for environmental education activities. The Landcare group is also currently compiling an environmental education folder outlining natural resources found in the Callide Valley, field trip options in the area, work sheets for students and resource material for teachers.

Many schools and Landcare groups in the other parts of the Fitzroy Catchment are undertaking similar activities, buying resources, developing educational packages and working together to present the students with more environmental education opportunities. There are more opportunities for students to learn about their environment today then there were fifteen years ago. The Friday Club has extended to all week club with paper and cardboard recycling being advanced with worm farms, raising tree seedlings, and planting theme gardens. Students are experiencing and learning practical knowledge of environmental issues relating to their area rather than overseas countries. Teachers have realised the benefits of telling, showing and involving their students when it comes to learning about their environment. The students are happy to share their experiences, allowing peer learning and also teaching the teacher (who may have grown up in a different centre, town, state or country).

Adult Community Activities

The community are very important in natural resource management. Information transfer is critical when sustainable production and developing natural resource management strategies are undertaken. All levels of the community need to be reminded that we all are responsible for downstream impacts on water quality. The Catchment Trailer provided an interesting and informative method of getting information out to the community.

The community needed to adopt the Catchment Trailer for their purposes, using the resources to deliver their information, messages and results. This meant removing the guardianship of the Trailer from the Department and persuading the community to share the Trailer. The Trailer wasn't always going to be administered by the Department and would eventually be handed over to the community to own and utilise.

Once the demand for the Trailer increased and the sampling activities became constant during reasonable seasons, the groups were required to collect the Trailer and set it up themselves. This allowed the groups to organise how long they needed the Trailer, plan the use of the Trailer and to work together on sharing the resource to achieve increasing awareness on catchment-wide land resource issues. Many groups would plan activities, school visits and meetings together, to book the Trailer so that they could best utilise it while they had it.

The Trailer has since been handed over to the Fitzroy Basin Association for the Waterwatch Coordinator to continue it's use as an awareness and information tool for catchment based issues. The coordinator's role is to organise the movements of the Trailer but it is the responsibility of the groups wanting the Trailer to arrange pick up and return to the next users. The Trailer is now a community-based resource, the continuing success is the responsibility of the community. The Department is responsible for passing on the information requested by the community for their decisions and implementing their strategies on natural resource management.

CONCLUSION

Education Activities

More schools will benefit from a visit by the Catchment Trailer. More students and teachers will learn from each other, from local Landcare members with local knowledge, and from people with different experiences and specialities. Environmental education is slowly but steadily enhancing the subjects and methods that students use to learn about their local catchment. The Catchment Trailer will be a valuable tool for implementing environmental education in all schools in Central Queensland.

Adult Community Activities

The community and the Department must work together to achieve sustainable natural resource management. The Trailer was the initial step to diffusing information into the community in a non-threatening and interesting way. The next step is for both parties to form strong partnerships to work together on the issues that affect both sides. Water quality is an issue in the Fitzroy Catchment that affects everyone. The awareness and knowledge of the community is increasing and has come a long way in the past three years. Sustainable natural resource management techniques in the Fitzroy Catchment are improving profit and yield, with this trend, knowledge on the impacts on water quality in the catchment should prevent quality decline.

3. Rainfall and Streamflow

Ian Wallace[1]

INTRODUCTION

An overall picture of the rainfall and runoff in the Fitzroy basin is contained in the report Downstream Effects of Land Use in the Fitzroy catchment - Summary Report December 1996. Chapter 2 of the 1996 report Rainfall and Streamflow - N. Kelly, Qld Department of Natural Resources, Rockhampton, describes the very high variability of the climate in the Fitzroy basin.

This variability exists from season to season, year to year, across groups of years and across different parts of the catchment. The extreme wet years were in the 1950s and 1970s. The north east of the catchment has the potential for extremely high rainfall and runoff events from cyclonic conditions far more so than the rest of the catchment.

METHODS

Rainfall measurements were obtained from Bureau of Meteorology records and from QDNR records. Streamflow and discharge data were obtained from QDNR stream gauging stations by standard procedures. Discharge rates were based on measurements using a current meter and obtained from DNR HYDSYS data.

RESULTS

Rainfall 1997-1999

Mean rainfalls indicate that parts of the upper Isaac catchment can receive more rainfall than in the Dawson and other drier parts of the Fitzroy basin. Rainfall figures are for climatic years 1st October to 30th September and show millimetres of rainfall.

Table 3.1: Rainfall measurements and mean annual rainfall for 1997-1999

	Mt Spencer (Upper Isaac)	Moranbah (Isaac)	Utopia Downs (Dawson)	Baralaba (Dawson)	Emerald (Nogoa)
Mean Annual	**879**	**598**	**672**	**724**	**644**
1996/7	1005	733	645	893	635
1997/8	780	668	896	818	722
1998/9	N/a	719	708	739	653

Streamflows 1997-1999

Runoff during the study period shows some very good flows in the Dawson. The figures are for climatic years 1 Oct to 30 Sep and show thousand megalitres of runoff.

[1] *Department of Natural Resources, Rockhampton, 4700*

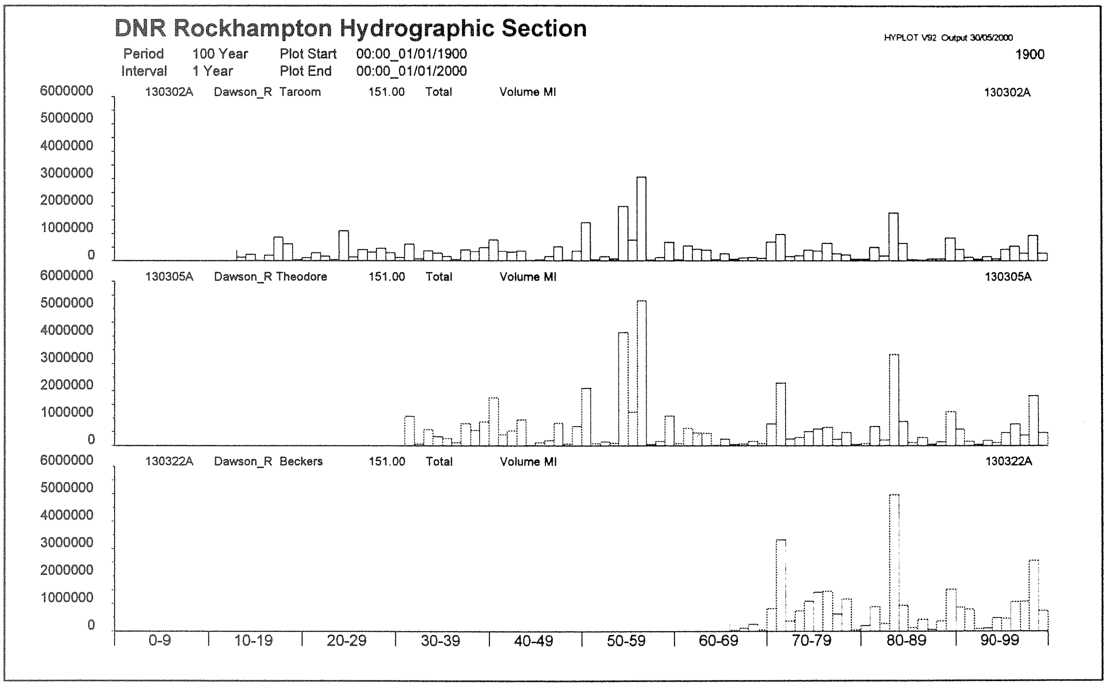
Table 3.2: **Runoff measurements and mean annual runoff for the study sites 1997-1999**

	Isaac	Comet	Nogoa	Upper Dawson	Dawson
Mean Annual	**2140**	**424**	*	**380**	**849**
1996/7	2160	162	167	283	1080
1997/8	530	174	292	887	2360
1998/9	1440	436	425	352	869

*too few years of record at this site downstream of Fairbairn Dam

During most years, and especially those years with higher flows as a result of widespread rain, there is a reasonably equal contribution of flow from the upper, middle and lower reaches of the Dawson.

Figure 3.1: Annual Total Discharges (ML) at Taroom, Theodore and Baralaba (Beckers) for the study period 1997-1999



Catchment area and contribution to runoff

The catchment areas of the sub-basins are shown in the following table. There is a good relationship between the contributions per square kilometre at Taroom, Theodore and at Baralaba. At the upstream sites there are only 25 years of records at Juandah Creek and only 33 years of records at Utopia Downs so the variability of runoff is likely to be more noticeable in these smaller catchments over shorter time periods. In particular, the Juandah Creek records started in 1974 so do not include the dry periods in the 1960s.

Table 3.3: Catchment area (km²), annual runoff (ML) and runoff depth (mm) for the five study sites

	Juandah	Utopia Downs	Taroom	Theodore	Baralaba Beckers
Catchment area (km^2)	1710	5955	15 720	27 350	40 585
Mean annual runoff (ML)	53 300	107 000	381 000	651 000	849 000
Mean annual runoff depth (mm)	31.2	18.0	24.2	23.8	20.9

During the study period, 1997 to 1999 the significant flows were comprised of roughly equal contributions from the upper middle and lower reaches of the Dawson. There was a particularly high flow event on 28 August 1998 in the upper part of the catchment. The 1998/99 flow through Juandah Creek was the highest annual total since records commenced in 1974 (after the wet season). The peak at Taroom was the highest since 1959. During the August 1998 event, there was rain in all parts of the catchment and there were good flows from all parts of the catchment. Lower flows are more likely to be localised in that they originate in a small pocket of the catchment.

Figure 3.2: Monthly Total Discharges (ML) at Theodore, Taroom and Baralaba (Beckers) for the Study Period 1997-1999

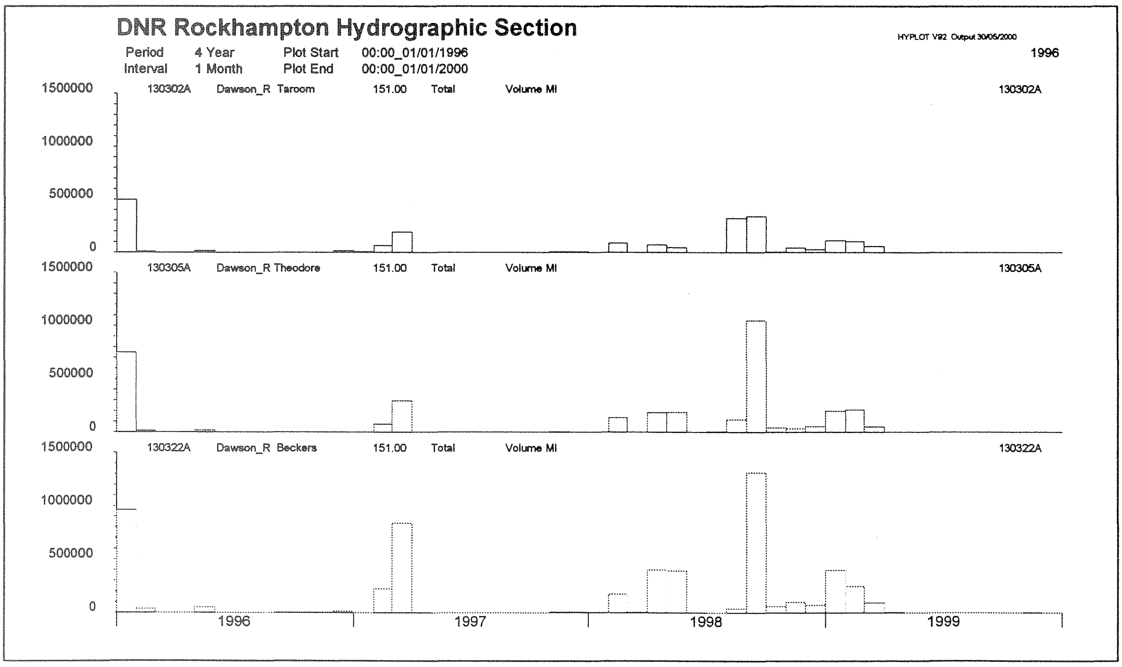


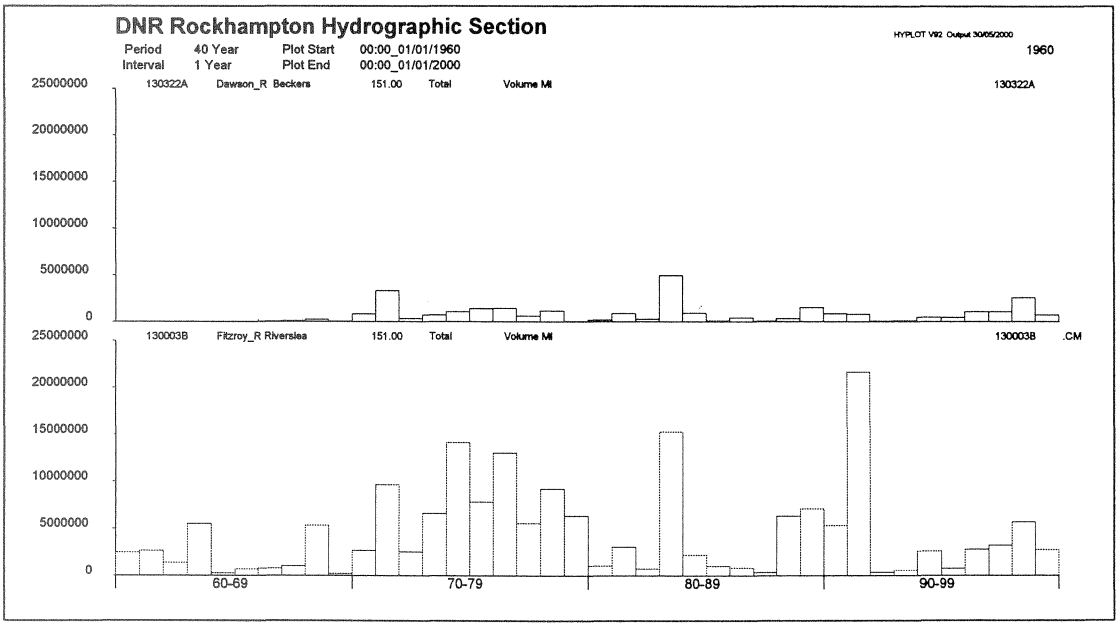
Table 3.4: Annual discharges in thousand megalitres

	Juandah	Utopia Downs	Taroom	Theodore	Baralaba Beckers
Mean Annual	**50**	**104**	**380**	**650**	**849**
1996/7	61	74	283	424	1080
1997/8	215	72	887	1770	2360
1998/9	43	92	352	706	869

Table 3.5: August 1998 event total discharges in megalitres

	Juandah	Utopia Downs	Taroom	Theodore	Baralaba Beckers
Mean Aug/Sep	7810	3860	17 400	35 800	62 200
Aug 1998	170 000	52 200	664 000	1 180 000	1 350 000

Figure 3.3: Annual Total Discharge (ML) comparison between Baralaba (Beckers) and Riverslea



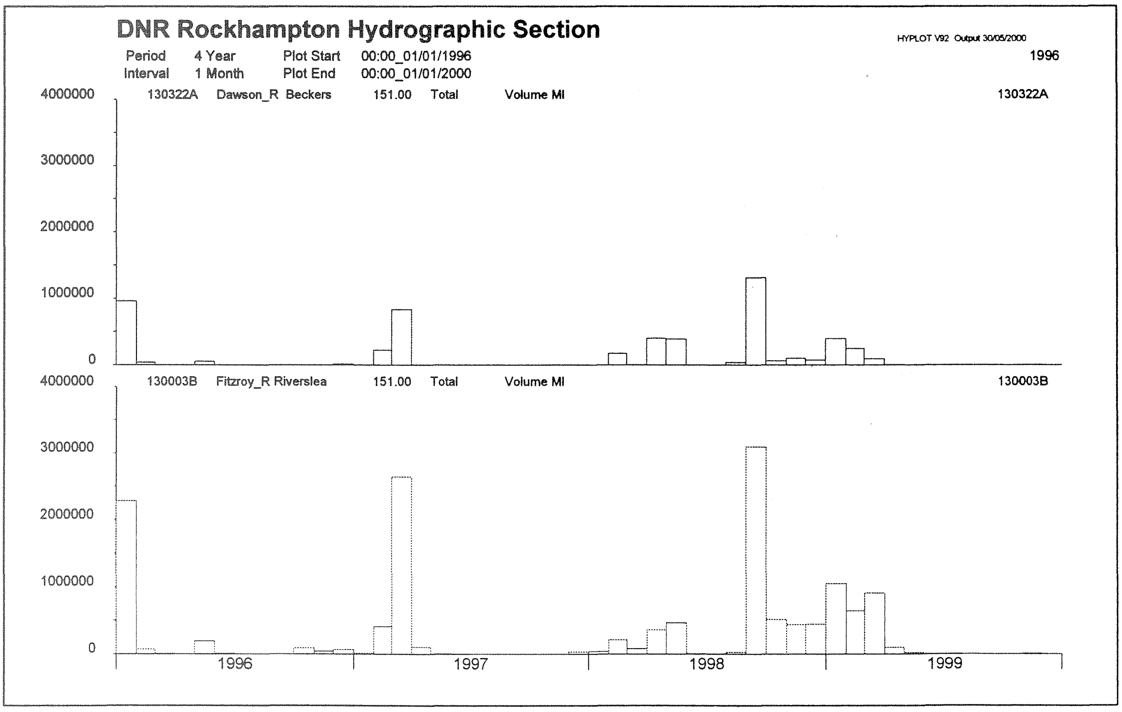
There is a trend for the Dawson water to be well mixed with other water in the Fitzroy during large flow events. This is primarily a function of catchment area and the significant flows that can originate in the Isaac River sub basin. When there is widespread rain and large flow events occur, the Dawson flows are a fairly small component of flow. On average the Dawson contributes about 850 000 megalitres (at Beckers) out of a total of 5 million megalitres (at The Gap) that flows down the Fitzroy. This contribution is about 17% of the total Fitzroy flow whereas the Dawson catchment (at Beckers) is 40 585 square kilometres out of a total of 136 000 square kilometres (at The Gap) or 30%.

During lesser flow events, there is always the likelihood that a small flow can originate in the Dawson and be the sole or predominant contributor to the Fitzroy. This can occur in winter and spring months. The records show that the mean summer flows can be much higher in the Isaac River but very comparable to the rest of the Fitzroy catchment in winter and spring. It is then that the Dawson is more likely to be the sole contributor to the Fitzroy system.

Table 3.6: Runoff depth (mm) for the five study sites

	Taroom	Theodore	Baralaba Beckers	Isaac River	Riverslea
Mean Annual	**23.8**	**23.8**	**20.5**	**106**	**36.8**
Summer	12.4	12.6	10.6	66.3	19.6
Autumn	6.0	6.0	6.5	38.9	14.4
Winter	2.6	2.7	1.7	2.2	1.9
Spring	3.0	2.4	2.3	1.8	2.3

Figure 3.4: Monthly Total Discharge (ML) Baralaba (Beckers) compared to Riverslea for the study period 1997-1999



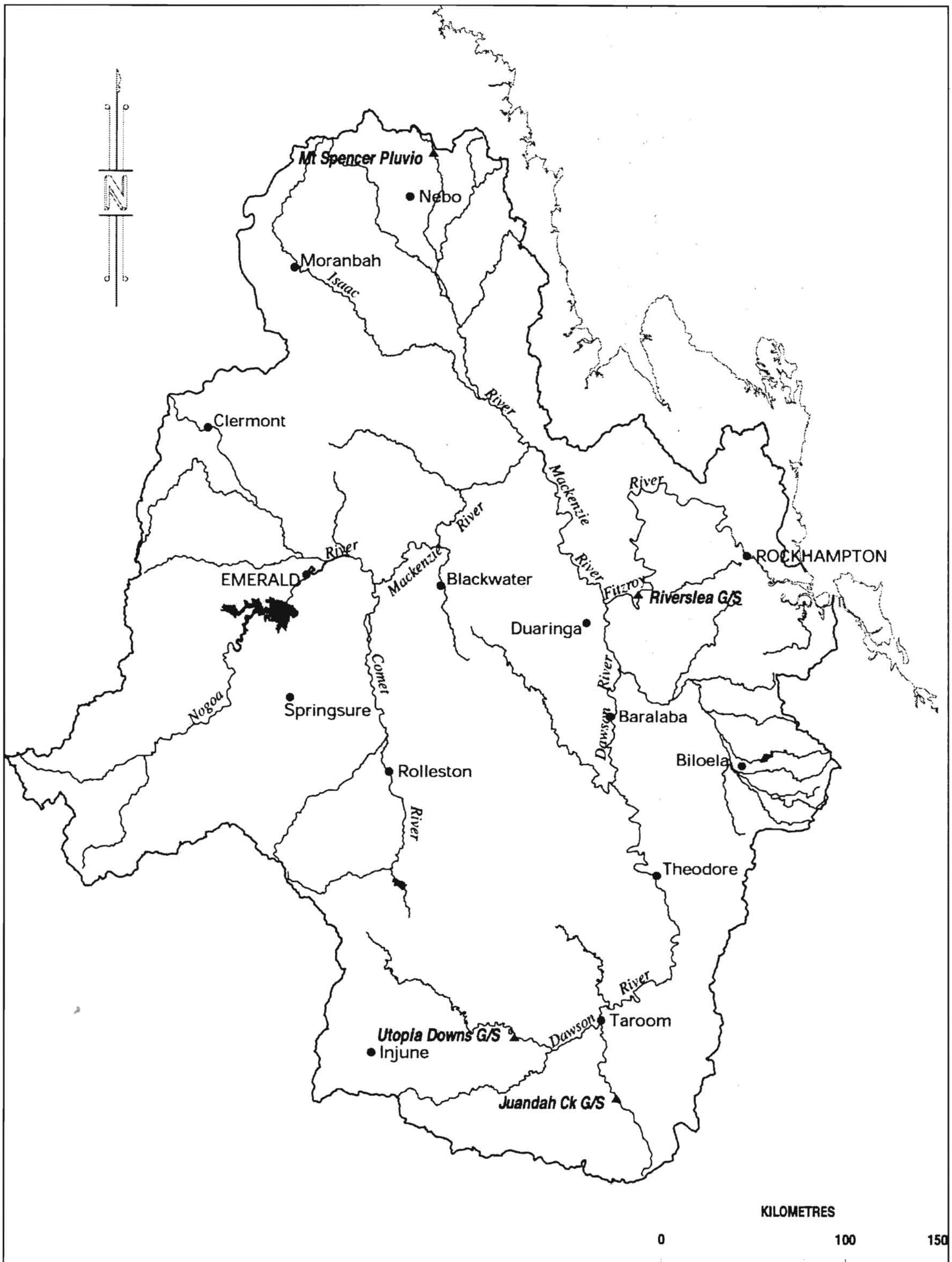
During the study period, the monthly totals coming out of the Dawson were mostly in conjunction with flows from the Isaac. However the period from April to May 1998 produced a reasonable flow from the Dawson, but there was little contribution from elsewhere. Flow at Tartrus weir is a good indicator of flow that did not originate in the Dawson, as it is just downstream of the confluence of the Mackenzie River and the Isaac River.

Table 3.7: Annual discharges in thousand megalitres

	Taroom	Theodore	Beckers	Tartrus	Riverslea
Mean Annual	**50**	**104**	**380**	**650**	**849**
1996/7	61	74	283	424	1 080
1997/8	215	72	887	1 770	2 360
1998/9	43	92	352	706	869

Any particular set of samples should be viewed in the context of flow and storage volumes. Where instream quality of water is the focus, small events that may be isolated to particular reaches of the Dawson are important. Large events are important in gaining a picture of the quantities of various elements and compounds that may move from the Dawson catchment to more downstream parts of the basin and the associated estuary and offshore areas. Map 2 shows sites where stream flows are recorded and can be used to focus on the water quality processes in a quantitative way.

Figure 3.5: Stream flow recording sites for the Fitzroy Catchment



4. Physical and Chemical Water Quality of the Dawson River

Bob Noble[1] *and Catherine Collins*[2]

SUMMARY

Water quality parameters were monitored at up to 11 sites along the Dawson River from Baroondah to Baralaba during 1997-1999, as part of a multi-disciplinary study to determine the state of health of the river ecosystem. These sites were classified as four Primary River Sites (two impounded and two riverine) and seven Secondary River Sites (Map 1). Parameters measured included physico-chemical indicators (temperature, dissolved oxygen (DO), pH, turbidity and light, suspended particulate matter (SPM)), nutrients (nitrogen and phosphorus) and pesticide residues. Results were interpreted against guidelines for fresh water quality in the draft Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Draft ANZECC 1999).

Levels of many of the parameters were clearly outside the draft guidelines. Many dissolved oxygen concentrations were low, especially for the impounded sites. Turbidity and suspended particulate matter (SPM) levels were much higher than the guideline values. Median nitrogen concentrations were at values between guideline levels for upland and lowland river types, while phosphorus levels were all much higher than the guideline values. Residues of a number of insecticides and herbicides were detected, detections being more common during summer. In many instances, concentrations exceeded guideline values when these were available. The herbicide atrazine was the most commonly detected pesticide. A number of pesticides commonly used in irrigated cotton production, including the insecticide endosulfan and the herbicides diuron, trifluralin, prometryne and fluometuron were also detected.

INTRODUCTION

During a previous multidisciplinary ecological assessment of stream health in the Fitzroy system (Noble *et al.* 1997) a number of key issues for water quality were identified for streams in the Fitzroy system, including:

- high concentrations (and loads) of suspended sediments (suspended particulate matter, SPM), especially after runoff events
- high concentrations (and loads) of nutrients (nitrogen (N) and phosphorus (P))
- detectable concentrations of a number of insecticides and herbicides, downstream from cropping areas especially during summer
- sporadic blooms of phytoplankton (algae) often dominated by cyanobacteria (blue-green algae)
- indication of reduced invertebrate richness in the vicinity of the Emerald Irrigation area
- low concentrations of dissolved oxygen, especially in impounded waters

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All but one of these factors were noted within the Dawson sub-basin. As well, all of the major land uses of the Fitzroy Basin; grazing, dryland and irrigated cropping, coal mining, forestry, national parks and urban areas, are present in the Dawson River valley. For these reasons and because of resource limitations, water quality studies in the current project concentrated on the Dawson River. The aim of this work was to assess the ecological health of the river and identify potential impacts of current land uses on this health. Changes in management practices can then be suggested if reductions in impacts are needed. Findings from this work will have relevance to other streams within the Fitzroy system.

METHODS

Sampling

Methods were similar to those previously outlined in Noble *et al.* (1997). Approaches to the collection of river water samples depended on the site, size of water body (stream) and the prevailing flow conditions at the time of sampling. The eleven sites, either on or closely associated with the Dawson River (Map 1) were classified as either Primary River Sites or Secondary River Sites, as outlined in Chapter 1. All sampling performed at the Primary River Sites was done under base flow or low flow conditions. Under moderate to high flow conditions, samples were taken mid-stream by surface dipping (0-25cm) from suitable structures over the streams (culverts, road bridges, weirs) or on limited occasions by casting from stream banks. Composite samples were taken mid-stream using a tube sampler from a dinghy.

Chemical analyses of water samples were carried out at the Resource Sciences Centre, Queensland Department of Natural Resources (QDNR) or at the laboratories of Queensland Health Scientific Services, both in Brisbane. These laboratories have a long history in agriculturally related analyses and NATA accreditation in major analysis methodology.

Physico-chemical

Temperatures and dissolved oxygen levels were measured *in situ* at a number of depths from surface to stream-bed at 1m intervals. Electrical conductivity and pH were recorded on-site. Surface samples taken under flow conditions might be expected to underestimate the suspended solid load being carried by the stream and also the load of substances possibly adsorbed on the suspended particles (phosphorus, pesticides). Previous results, however, from more rigorous sampling undertaken in flood conditions in the lower Fitzroy (Kelly & Wong 1996) seem to indicate that the average suspended solid concentration is not very different from that measured near the surface. After collection, "flow" samples were treated similarly to those taken under base flow conditions. Concentrations of SPM were established in the laboratory by filtration of a representative sample through a glass microfibre filter (nominal pore size 0.45μm).

Nutrient

Representative samples for nutrient analysis were placed in 1L polyethylene bottles previously acid washed and rinsed with high quality laboratory water (quality exceeds all standards for Type 1 Reagent Grade water). Samples for nutrient analysis were initially cooled on-site in "eskies" or portable refrigerators and frozen until sent to the laboratory for analysis.

Pesticide

Samples for pesticide residue analysis were placed in 1L borosilicate glass bottles that had previously been rinsed with analytical grade ethanol and acetone. They were then cooled on-site in "eskies" or portable refrigerators then freighted by air to the laboratory within 48 hours for analysis.

Pesticide detection analyses were performed by the Pesticide and Product Quality Division of the Resource Sciences Centre, Queensland Department of Natural Resources, Indooroopilly, Brisbane. Samples (unfiltered) were extracted with dichloromethane and hexane and the concentrated extracts analysed for selected organochlorine, organophosphate, triazine and other residues by GC/MS. Compounds included in the analysis with their detection limits are presented in Table 4.1. The samples were also screened for Diuron and Fluometuron, using High Performance Liquid Chromatography. Detection limits were 1.5μg/L and 1μg/L respectively.

Table 4.1: Pesticides included in the analysis and their detection limits

Compound	Detection Limit (μg/L)
α - Endosulfan	0.20
β - Endosulfan	0.20
Endosulfan Sulphate	0.20
p,p-DDE	0.20
Profenofos	0.20
Trifluralin	0.10
Prometryn	0.20
Atrazine	0.20
Hexazinone	0.50
Tebuthiuron	0.50

Interpretation of results

Water quality results were interpreted in terms of the Draft Australian and New Zealand Guidelines for Fresh and Marine Water Quality, (Draft ANZECC 1999) and where appropriate the Australian Drinking Water Guidelines (NHMRC & ARMCANZ 1996). An attempt was made within the ANZECC documents to arrive at guidelines that are relevant to Australian conditions. While this is laudable, the ideal protocols used to derive guidelines rely heavily on data from reference (non-impacted) sites for the region of interest. If such sites or data are not available (as is the case for the Dawson River), then interim trigger levels, derived from Australian data sets, are used. Unfortunately, these Australian data sets seem not to include any Queensland data. There is also an element of subjectivity in deciding the degree of disturbance of the ecosystem being studied and in the classification of river sections as "upland" or "lowland".

In the following discussion, the Dawson River is considered as a "slightly to moderately disturbed" ecosystem and data for the river are compared with interim trigger levels for both "upland" and "lowland" rivers.

RESULTS AND DISCUSSION

Table 4.2: Mean, median and range values for the 10 water quality parameters measured

	Mean	Median	Range	Number of samples
Temperature (°C)	23.8	25.1	9.1-32.4	227
Dissolved oxygen (mg/L)	6.6	6.9	2.9-11.7	109
pH	7.6	7.7	6.2-8.7	87
Surface EC (µS/cm)	198	208	89-364	88
Composite EC (µS/cm)	182	182	25-1125	235
Turbidity (Secchi, m)	0.29	0.17	0.05-1.9	116
SPM (mg/L)	185	181	7-1169	206
Nitrogen (µg/L)	830	820	150-2300	73
Phosphorus (µg/L)	201	200	19-580	73
TN:TP ratio	5.1	4.1	1.1-13	73

Physico-chemical indicators

Temperature

Water temperatures measured during the study ranged from 9.1°C to 37.9°C. For 227 composite water samples, the mean, median and range values were 23.8, 25.1 and 9.1 to 32.4°C respectively. For the Primary River Sites, water temperature profiles from surface to streambed were recorded. Differences in temperature between surface and streambed ranged from low values showing that the water bodies were well mixed, to quite high values indicating that the water was stratified. Most of the large differences, not surprisingly, were recorded in the impoundments, but not exclusively so. Differences of 11.5, 16.4, 10.7 and 14.3°C were noted for Glebe Weir, Moura Weir, Orange Creek Weir and the riverine site, Woodleigh, respectively and the depth at Woodleigh for that December sampling was only three metres.

Dissolved Oxygen (DO)

Interim trigger levels for DO are:

- 90%-92% saturation (approximately 6 mg/L, Draft ANZECC 1999).

No consideration was given to the diurnal variations expected in dissolved oxygen levels. All readings were taken between dawn and dusk. For the 109 surface (0-25cm) samples, the mean, median and range were 6.6, 6.9 and 2.9 to 11.7mg/L respectively. While the mean and median values are greater than 6mg/L, 42 of the 109 readings were less than this trigger level. Most of these low DO values were recorded for impounded waters, while ten were from riverine sites. About 100 DO profiles (surface to streambed) were taken for the Primary River Sites, (Map 1, sites 2,3,6 and 7). Some low DO values (<6mg/L) were recorded for surface samples from all of these sites. These low surface concentrations were invariably associated with even lower values at depth. Anoxic conditions at depth were common especially for the impounded waters of the Moura Weir (see isopleths of dissolved oxygen in Moura Weir in Chapter 5).

pH

Interim trigger levels for pH are:

- 6.6-8.0 for lowland rivers
- 6.5-7.5 for upland rivers
- 7.8-8.3 for freshwater lakes and reservoirs (Draft ANZECC 1999), and
- 6.5-8.5 from the Australian Drinking Water Guidelines (1996).

The pH data for 87 surface samples showed mean, median and range values of 7.6, 7.7 and 6.2 to 8.7 respectively. While some of these values are obviously outside the interim trigger ranges for the ecosystem types listed above and for the Australian Drinking Water Guidelines, most lie within. All pH values greater than 8 were recorded in the summer period (October to March) and all pH values of less than 7 were recorded outside this summer period. Most high values were associated with the Moura Weir in summer, and in some instances, associated with algal blooms (Chapter 5).

Electrical Conductivity (EC)

Interim trigger levels are:

- 500μS/cm for lowland rivers
- 110μS/cm for upland rivers and
- 60μS/cm for freshwater lakes and reservoirs (Draft ANZECC 1999).

The EC data for 88 surface water samples showed mean, median and range values of 198, 208 and 89 to 364μS/cm respectively. These values lie comfortably within the desirable range for upland and lowland river systems. The data for 235 composite samples taken from surface to streambed showed mean, median and range values of 182, 182 and 25 to 1125μS/cm respectively. All but two of these values were <500μS/cm. A reading of 551μS/cm was recorded for Juandah Creek, and a value of 1125μS/cm for Delusion Creek. The reading for Delusion Creek was for a clear low flow presumably arising from groundwater incursion.

Light and Turbidity

Interim trigger levels for suspended particulate matter (SPM) and turbidity in slightly to moderately disturbed ecosystems (Draft ANZECC 1999) are shown in Table 4.3.

In the current work, water clarity and turbidity were estimated using a Secchi disk and light meter at the Primary River Sites and thus were measured under base flow or low flow conditions only. Turbidity would be expected to increase under high flow conditions. For 116 Secchi readings, the mean, median and range were 0.29, 0.17 and 0.05 to 1.9 m respectively. This compares with a median value of 0.23 m in previous work (Noble *et al.*, 1997). Light meter readings and interpretations are detailed in Chapter 5.

Table 4.3: SPM and turbidity interim trigger levels (Draft ANZECC 1999)

	SPM (mg/L)	Turbidity (NTU)
Lowland rivers	6	10
Upland rivers	2	5
Freshwater lakes and reservoirs	2	4.5

Suspended Solids (Suspended Particulate Matter – SPM)

The Dawson River is turbid during flows and at most locations for most of the time remains fairly turbid between flows. Anecdotal evidence suggests that this was not always the case. For 206 samples taken during the study, SPM data showed mean, median and range values of 185, 181 and 7 to 1169mg/L. This median value of 181mg/L for the Dawson River is slightly higher than the median value of 157mg/L recorded previously for surface waters of the Fitzroy system (Noble *et al.* 1997). When flow data were available, samples were divided into high flow (greater than 20th percentile) and low flow categories. The mean and median SPM values for 31 high flow samples were 398 and 387mg/L respectively, while corresponding results for 129 low flow samples were 128 and 122mg/L. Even the low flow SPM data for the Dawson River greatly exceed the suggested guidelines for either upland or lowland river types (Table 4.3). Either the guidelines are inappropriate for this type of sub-tropical river or the river must be considered as severely degraded.

Nutrients

Interim trigger levels of nutrients (total nitrogen (TN) and total phosphorus (TP)) for slightly to moderately disturbed ecosystems under low flow conditions are detailed in Table 4.4.

Table 4.4: Nitrogen and phosphorus interim trigger levels (Draft ANZECC 1999)

	Total nitrogen (µg/L)	Total phosphorus (µg/L)
Lowland rivers	1600	37
Upland rivers	340	35
Freshwater lakes and reservoirs	440	50

Without clearer criteria in the Draft ANZECC (1999) guidelines it is difficult to classify sections of the Dawson River as either uniquely "upland" or "lowland" types. Nutrient data for the Dawson River from this study are therefore compared with values for both the upland and lowland types.

Nitrogen

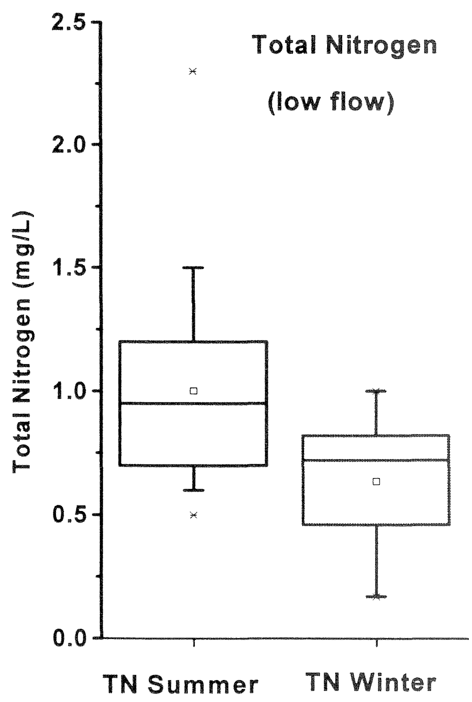
For the 73 composite water samples, TN values for mean, median and range were 830, 820 and 150 to 2300µg/L respectively. When samples were split into high flow (20th percentile) and low flow, mean and median values for TN were 849, 900 and 820, 790µg/L respectively. Thus, as expected, median TN values were marginally lower for the "low flow" samples. Under low flow conditions at Widewater on the "upper" Dawson River, values of TN>1000µg/L, well above the "upland" trigger level of 340µg/L and approaching the "lowland" trigger level of 1600µg/L were recorded. The mean and median levels of TN for both the high and low flow samples lie between the guideline trigger levels of TN for upland and lowland river systems. Thus, for a satisfactory interpretation of the TN data for the Dawson against the ANZECC 1999 guidelines, the river, or parts thereof, needs to be confidently classified as either "upland" or "lowland" types. This does not seem possible within the criteria given.

For 32 samples, nitrogen associated with SPM (filtration at 0.45µm) and nitrogen in the aqueous phase were determined separately. The median percentage of the TN associated with SPM was 31% but this ranged from 5.9% to 56.1%, showing that the forms of nitrogen in the river may vary widely.

For the soluble N fraction, the percentage of N species ranged from 2 to 16% for NH_4, from not detected to 58% for $NO_3 + NO_2$ and from 39% to 96% for dissolved organic nitrogen (DON). This wide range in the different forms of nitrogen will be reflected in large variations in the bioavailability of the nitrogen for uptake by aquatic flora.

There appears to be a seasonal factor in the nutrient data for the four Primary River Sites even when only "low flow" samples are included. The median TN value (n=30) for summer samples (October to March) was 945µg/L while for winter samples (April to September, n=24) this value was 695µg/L (Fig. 4.1). Flows occur more commonly in the summer period so although these samples were taken under low flow conditions, nutrient results may have been influenced by prior flows. This was recently shown for flows in the lower Fitzroy catchment (Fabbro & Duivenvoorden 2000). Additionally, the relationship between summer and winter TN values appears to differ for impounded and riverine sites. If the median TN value for winter is expressed as a percentage of the TN value for summer then percentages were 94% and 70% for the Glebe and Moura Weirs and 26% and 56% for the riverine sites

Figure 4.1: Comparison of total nitrogen (low flow) values for summer and winter



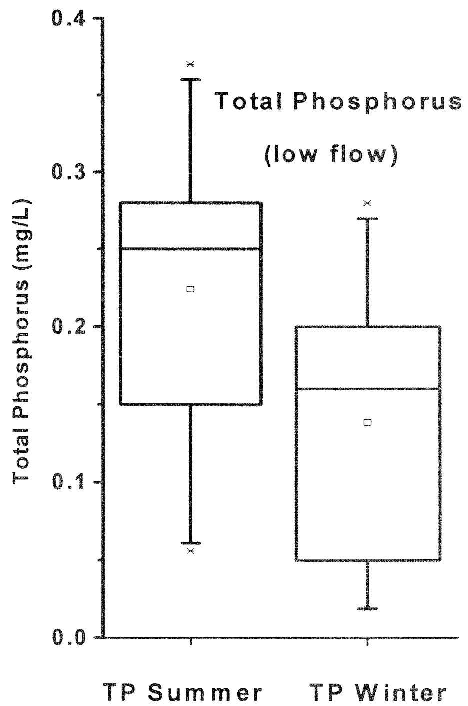
Widewater and Woodleigh. For the upper Dawson site at Widewater then, the river water contains about one quarter as much nitrogen in winter compared with summer. For Woodleigh this figure is about one half (Fig. 4.3).

Phosphorus

For the 73 composite water samples, TP values for mean, median and range were 201, 200 and 19 to 580µg/L. When samples were split into high flow (20^{th} percentile) and low flow, mean and median values for TP were 280, 260 and 182, 200µg/L respectively. Thus, as expected, TP values were higher for the "high flow" samples. The mean and median values for TP for the Dawson River for both the high and low flow samples greatly exceed, by almost an order of magnitude, the guideline trigger levels for both upland and lowland river types in the Draft ANZECC guidelines (1999). These TP values for the Dawson compare with a similar median TP level (n=102) of 215µg/L from previous work (Noble *et al.* 1997).

Much of the phosphorus is probably derived from natural erosive processes. TP values about twice the guideline trigger levels are recorded for low flow conditions at Baroondah (site 11, Map 1) an upper Dawson River site, upstream of any major anthropogenic inputs of phosphorus apart from forestry and grazing. To be appropriate for central Queensland conditions, the guidelines need to take into account these naturally high background levels of phosphorus. For 60 samples, phosphorus associated with SPM (filtration at 0.45µm) and phosphorus in the aqueous phase were determined separately. The median percentage of TP associated with SPM was 62% but this ranged from 21% to 85% showing that the proportion of phosphorus in the river water that is soluble varies considerably. For the soluble phosphorus fraction, the percentage of phosphorus species ranged from 25% to 88% for PO_4 and 13% to 75% for organic phosphorus, indicating the bioavailability of phosphorus in the water

Figure 4.2: Comparison of total phosphorus (low flow) values for summer and winter

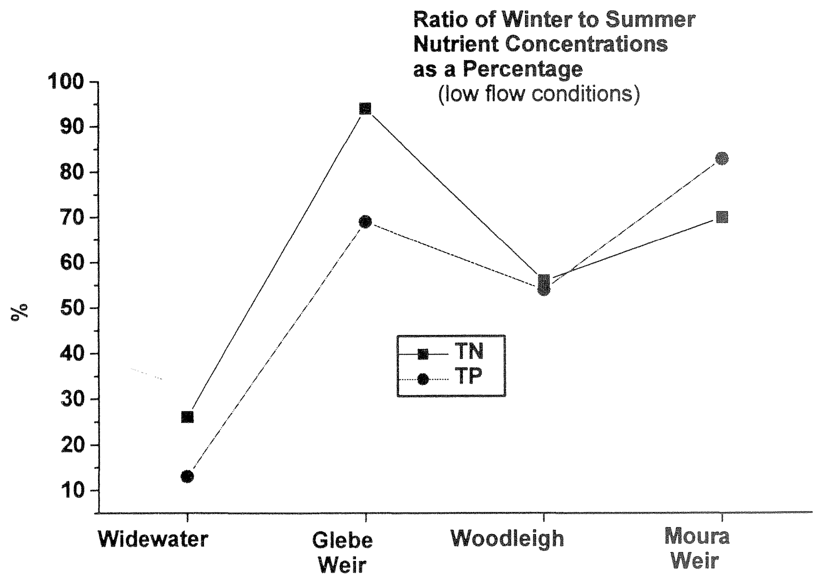


would also vary considerably.

The strong association between phosphorus and SPM in waters from rivers has been widely noted and was recorded previously for the Fitzroy system (Noble *et al.* 1997). There appears to be a seasonal factor involved in TP levels as there was for TN, even when only " low flow" samples are considered (Fig. 4.2). For summer samples (October to March, n=30) the median TP value was 245µg/L, while for winter samples (April to September, n=24), this value was 155µg/L. The higher median TP value for the summer samples, however, can't be fully explained by the only marginally higher median level of SPM for the summer samples (summer median=168µg/L, winter median=148µg/L).

As for TN, the relationship between summer and winter TP values appears to differ for impounded and riverine sites. If the median TP value for winter is expressed as a percentage of the TP value for summer then percentages were 69% and 83% for Glebe and Moura Weirs and 13% and 54% for the riverine sites Widewater and Woodleigh (Fig. 4.3). The median SPM values for summer and winter samples are similar for the impoundments (Glebe and Moura Weirs) but for the riverine sites the winter median SPM values are much lower, especially for Widewater. The riverine sites are more likely to "clear" in winter than the impounded water and this probably explains the lower winter TP percentages for the riverine sites. Although the data sets are small and care should be taken with interpretations, it is interesting to note that for the riverine sites, the median winter SPM levels are much lower at Widewater (upper Dawson) than at Woodleigh, which is downstream from four weirs and the Theodore irrigation area.

Figure 4.3: Ratio of winter to summer nutrient concentrations



Data for separate nitrogen and phosphorus species (filtered and unfiltered samples) are available for many of the river water samples. For brevity this detail is not included in the report.

TN/TP Ratios

Correlation of TN to TP values for 73 samples gave r=0.748. The limitations in using total nitrogen to total phosphorus (TN:TP) ratios as a guide to potential blue-green algal growth problems has been documented (ANZECC 1992; Draft ANZECC 1999). In assessing the risk of blue-green algal blooms more site-specific physico-chemical, chemical (concentrations of N and P species) and biological data are required.

In the current study, for 73 Dawson River water samples, the mean, median and range for TN:TP ratios was 5.1, 4.1 and 1.1 to 13. These low values agree with data previously measured for the Fitzroy system (Noble *et al.* 1997). While most of the higher values were noted for the upper Dawson sites, some of these sites (Tarana Crossing, site 10; Juandah Creek, site 9; Glebe Weir, site 6: Map 1) also showed some low TN:TP ratios.

Waters of the Dawson system are now normally fairly turbid as illustrated by SPM, Secchi disk and light data in the current study. While nitrogen and phosphorus

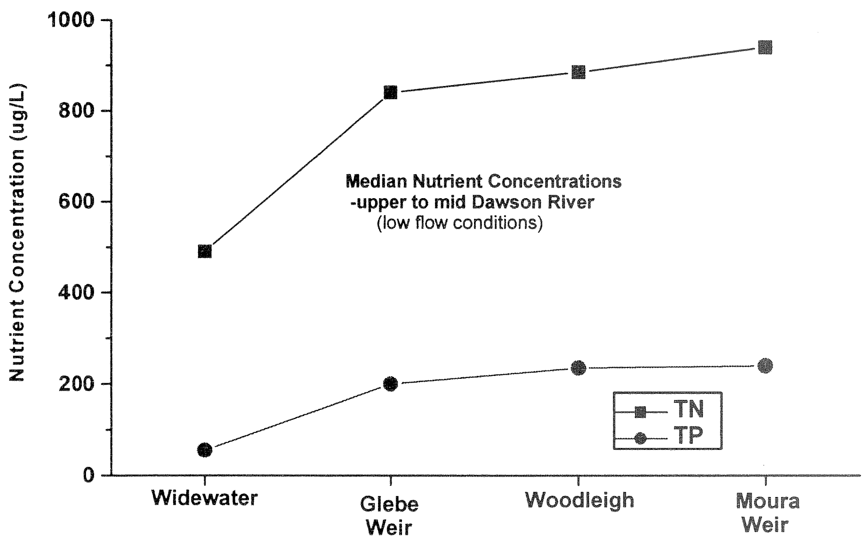


Figure 4.4: Changes in median nutrient concentrations from the upper to mid Dawson River under low flow conditions.

concentrations are often above guideline trigger levels, the turbidity may limit phytoplankton growth. A blue-green algal bloom occurred in Moura Weir during the course of this study after "clearing" of the water column in early summer. This event is described in detail in Chapter 5.

Changes in nutrient status from "upper" to "mid" Dawson River sites

For the Primary River Sites under low flow conditions, there is a progressive increase in the median values for TN and TP in going from the "upper" riverine site at Widewater, through four weirs to the "mid" Dawson sites at Woodleigh and then Moura Weir (Fig. 4.4). For Widewater, Glebe Weir, Woodleigh and Moura Weir, median TN and TP concentrations (µg/L) are shown in Table 4.5.

Table 4.5: Median TN and TP values for the four Primary River Sites on the Dawson River

	Median TN (µg/L)	Median TP (µg/L)
Widewater	490	55
Glebe Weir	840	200
Woodleigh	885	235
Moura Weir	940	240

Some increase in nutrient concentrations from natural erosive processes might be anticipated for sites progressively further downstream but human inputs probably play a part also, with increasing activities in grazing, cropping, irrigation, coal mining and urban land uses occurring between Widewater and Moura Weir. A nutrient budget and studies of nutrient cycling within the system would be required to clarify the importance of different nutrient inputs.

Pesticides

The task of providing guideline levels for toxicants (including pesticides) to maintain the integrity of aquatic ecosystems continues on national and international fronts. The approach to guideline levels for pesticides in the Draft ANZECC, 1999 document is to establish three grades of guideline trigger levels:

- Level 1 – the highest grade – derived from multiple species data – highest confidence
- Level 2 – derived from acute toxicity data – lower confidence in extrapolation methods
- Interim or tentative guideline trigger level – derived in the absence of a data set of sufficient quantity

In this project, during 1997-1999, 239 water samples from the Dawson River were taken for pesticide analysis. Sites ranged from the upper Dawson at Baroondah (site 11, Map 1) to the lower Dawson at Baralaba (site 1, Map 1). There was some planned seasonal bias in this sampling program for pesticides, with 62% of samples taken in the summer period (October to March) and 38% in winter (April to September). This was done to reflect the higher inputs and potential offsite loss to streams, of pesticides in the summer cropping cycles. The water samples were analysed for a suite of pesticides determined by knowledge of pesticide use in the valley and detections in previous work (Noble *et al.* 1997). The suite of pesticides, which for cost limitations was not all-inclusive, and limits of detection are listed in Table 4.1. For the 239 water samples, one or more pesticides were detected in 62 (26%) of the samples.

Atrazine

As in the previous study of the whole Fitzroy system (Noble *et al.* 1997), the herbicide atrazine was the most commonly detected pesticide with 55 detections. Residues of atrazine were found along the length of the Dawson from Tarana Crossing (site 10, Map 1) to Baralaba (site 1, Map1) but not at the upper Dawson site of Baroondah (site 11, Map1). As atrazine is commonly used in the summer cropping cycle, not surprisingly 80% of these detections were in summer (October to March). Concentrations detected ranged from the limit of detection to 2.02µg/L, with a median value of 0.18µg/L. The highest level was found at Juandah Creek (site 9, Map 1) in December 1997. A Level 1 guideline trigger concentration of 0.5µg/L has been assigned (Draft ANZECC 1999). Only four of the detections were above this guideline level.

Endosulfan sulfate

Eleven detections of the insecticide endosulfan sulfate were made, all between Theodore and Moura (sites 2,3 and 4, Map 1) and all during the summer period. Concentrations ranged from 0.01 to 0.2µg/L. A Level 1 guideline trigger concentration of 0.001µg/L has been set (Draft ANZECC, 1999) so that all detections in the current study were above this trigger level.

Diuron

Sixteen detections of the herbicide diuron were recorded. As for endosulfan sulfate, all these detections were made between Theodore and Moura and all in the summer period. Concentrations ranged from 0.2 to 2.31µg/L with a median of 1.04µg/L. Insufficient data are available for diuron for trigger levels to be set, however an Environmental Concern Level (ECL) of 0.03µg/L has been suggested (Draft ANZECC 1999). In the current study, all detections of diuron were above this ECL concentration. Traces of diuron along with DDE have been reported recently in subtidal sediments at the mouth of the Fitzroy River (Haynes *et al.* 200?).

Profenofos

Six detections of the organophosphorus insecticide profenofos were made. These were all in the Orange Creek Weir to Woodleigh section (sites 3,4,5, Map 1) of the Dawson River and all in the summer. Concentrations ranged from 0.03 to 0.12µg/L. A trigger guideline level has not been set but a very low ECL of 0.00002µg/L has been suggested (Draft ANZECC 1999) for freshwater. All of the concentrations detected were well above this ECL level.

Trifluralin

The herbicide trifluralin was only detected once. The concentration was below the Level 2 trigger guideline value of 1µg/L.

Prometryn and Fluometuron

Several detections of the herbicides prometryne and fluometuron were also recorded, all in the Theodore to Moura section of the river and all in summer. Currently, guideline levels are not available for these compounds.

In this study, the sampling frequency for pesticides was not high. The data suggest that if this frequency was high and targeted the irrigation reaches of the river in summer, a suite of pesticides, often at concentrations above guideline trigger levels, would be commonly detected. This conclusion is supported by other data (Drainage Management Study, Emerald Irrigation Area 1998) that show high concentrations of pesticides in some drains and creeks within irrigation areas in the Fitzroy Basin. To improve this situation and help maintain the ecological integrity of our streams, management practises within the cotton industry should be aimed at retaining soil and water within the paddock and where this is not feasible, runoff should be held in off-stream storages for recycling. Current moves within the industry, through Best Management Practices including recycling of tailwater and agronomic changes (e.g. retention of wheat stubble to minimise soil loss) should be strongly supported.

The current and previous data for atrazine strongly suggest that the residues detected in the Dawson River are arising from the common use of this herbicide in the dryland summer cropping cycle (Noble *et al.* 1997). Atrazine may be seen as an essential component in the viability of these cropping enterprises. However, the ubiquitous detection of atrazine in surface water samples throughout the Fitzroy Basin and growing concerns in Australia and overseas about its impact on aquatic ecosystems, reinforce the need to minimise the use of the herbicide and its movement offsite into streams. Targeted spraying and integrated weed control measures should be strongly encouraged.

CONCLUSIONS

From the data in this and previous studies, water quality along most of the Dawson River is reasonable, if pristine conditions are not expected (Noble *et al.* 1997; National Land & Water Resources Audit 2000). With the quite high concentrations of nutrients, especially phosphorus, algal growth is probably limited not by the availability of nutrients but by light as the waters remain turbid for most of the time at least in the mid and lower reaches. From anecdotal evidence, this level of turbidity was not the norm before fairly intensive agricultural development of the valley by Europeans.

With six weirs along the Dawson, large portions of the river consist of impounded water. Low levels of dissolved oxygen, water levels that often fluctuate and limited habitat in the impoundments mean that these reaches are not ideal for supporting abundant and diverse aquatic flora and fauna.

Low concentrations of the herbicide atrazine are present probably for most of the time, in much of the river, at least downstream from about Taroom. As well, during each summer, the river downstream from Theodore contains low concentrations of a number of insecticides and herbicides associated with irrigated cotton production.

Concentrations of these pesticides are probably attenuated in the lower reaches of the Dawson and the Fitzroy Rivers. The impacts of these pesticides, present mostly at sub-lethal levels, on the aquatic flora and fauna are not well understood but are probably significant and further studies should clarify these issues.

The pressures on the river ecosystem of the Dawson Valley are thus considerable and much of the river should be regarded as moderately degraded. Improvement could be achieved by removing some of the impoundments. If the status quo is to be maintained, then understanding the impacts of the agricultural chemicals needs to be addressed, and minimising the exposure of the river ecosystem and its biota to these chemicals should be a high priority.

If further substantial water extraction and agricultural development is to take place along the Dawson, then this should be accompanied by extensive measures to minimise further pressures on the river. As has been witnessed elsewhere in Australia, for rivers, the line between moderately and severely degraded is difficult to see but not to cross.

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5. Phytoplankton of the Dawson River and Implications for Future Water Quality Monitoring and Management within the Fitzroy River Catchment.

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INTRODUCTION

The analysis of river conditions, flow regimes and corresponding phytoplankton populations is valuable in determining optimal flow regimes and other management techniques for maximizing water quality. Phytoplankton are rapid indicators of water quality. They are primary producers at the bottom of aquatic food webs and as such, provide a vital food source for microscopic animals. They themselves may dictate water quality at times where the most common algal forms are cyanoprokaryotes (cyanobacteria or blue-green algae). Cyanoprokaryotes may produce unpleasant tastes and odours or very potent toxins. Large toxic blooms of some strains of these organisms may render the water unsuitable for human or animal use. In various areas of the Fitzroy catchment the success of cyanoprokaryotes is thought to be enhanced by the impoundment of water.

This project targeted the analysis of phytoplankton populations, flow regimes and river conditions at selected impounded and riverine sites along the Dawson River during 1997 and 1998 to examine differences between impounded and riverine waters and the factors which predispose to cyanoprokaryote blooms. Initially it was hoped to sample 2 impounded and 2 riverine sites, however, safety concerns associated with flow releases meant that only 1 impoundment (Moura Weir) and 1 riverine site (Woodleigh) could be studied in detail. The aim of this work was to identify general patterns in the data that are applicable to water management and control of factors triggering algal blooms throughout the Fitzroy River Catchment and build on the information already obtained in the previous Downstream Effects of Land Use in the Fitzroy Catchment project (Noble *et al.* 1997).

A large number of other sites were surveyed during the project so that patterns of algal abundance and dominance could be identified at selected sites along the Dawson River and information on the presence/absence of potentially toxic cyanoprokaryotes at these sites could be made available to water managers. This work also aimed to provide scientifically accurate data for distribution to the community in order to increase the awareness of water quality issues.

METHODS

Phytoplankton was sampled so as to provide an integrated sample from the entire water column at selected impounded and riverine sites along the Dawson River during 1997 and 1998. Moura Weir (capacity 7265 ML) and the riverine site of Woodleigh were monitored in detail between May 1997 and March 1998. Data on physical and chemical conditions (Noble & Collins, Chapter 4) and the other biota (Chapters 6 & 7) present within the water column were collected at the same time as the phytoplankton samples.

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Water samples for phytoplankton analysis were preserved immediately after collection using 1% Lugol's Iodine and transported to the laboratory where they were concentrated by sedimentation and algal populations subsequently counted in a calibrated glass Sedgwick-Rafter Counting Chamber. Counts were made of all cells in a minimum of 100 units (cells, trichomes or colonies) except in those few cases where a mix of high sediment loading and extremely low cell numbers meant that 100 units were not available for counting. In these instances of low cell numbers, the count was based upon the number of cells present in 40 Sedgwick-Rafter squares.

RESULTS AND DISCUSSION

Two important issues were identified by the analysis of phytoplankton populations. One was the dominance of the phytoplankton by cyanoprokaryotes (blue-green algae) when cell concentrations were highest (Fig. 5.1). The other was the occurrence of low cell concentrations at times of high sediment load (Figs 5.2b & 5.2c). Samples of lowest cell concentration were often dominated by cryptophytes. Low cell concentrations may be of concern as algae are important oxygenators of the water column and a source of food for various invertebrates. Decreased populations of photosynthetic algae may also include contamination of a water column by herbicides. Similar findings in relation to population structure and dominance were obtained in the earlier study of various selected sites throughout the Fitzroy River Catchment (Fabbro & Duivenvoorden 1997), reinforcing the applicability of findings from this data set to the river system as a whole. A total of 134 species of phytoplankton were identified during this study. This contained diatoms (20), chlorophytes (34), euglenophytes (44), dinoflagellates (5), chrysophytes (2), cryptophytes (2 species) and cyanoprokaryotes (27).

Moura/Woodleigh

The wax and wane of phytoplankton populations at Moura Weir and Woodleigh was determined by the flow regime and subsequent concentration of suspended solids within the water column. Downstream inflows into Moura Weir were gauged at Woodleigh and were greatest in the late summer and early autumn and lowest in the winter (Fig. 5.2). Concentration of suspended sediment in Moura Weir followed a pattern of highest values in the winter and spring with reduced concentrations and accompanying increased penetration of light within the water column in the summer (Fig. 5.2). This increased penetration of light into the water column coincided with an increase in the phytoplankton cell concentration in Moura Weir. Phytoplankton concentration decreased markedly in March 1998 following flows peaking at 23 194 ML day^{-1} on 16th February (Fig. 5.2). In contrast, at the riverine site Woodleigh, concentrations of suspended sediments (SS) fluctuated more than in the impounded waters of the Moura Weir and responded to flows from upstream. The SS concentrations at Woodleigh were comparatively low during the winter of 1997, increased during August to October in response to flows, decreased from October to November and then increased again in response to flows of mid November 1997 (Fig 5.2.d). Phytoplankton populations stayed relatively low at Woodleigh during all of this time (Fig. 5.2.c).

A cyanoprokaryote bloom (i.e. greater than 15 000 cells/mL of water) containing predominately straight *Cylindrospermopsis raciborskii* was detected in Moura Weir between 22 December 1997 and 9 February 1998 (Figs 5.2 and 5.3). Straight

Cylindrospermopsis from elsewhere in the Central Queensland region is known to produce the toxin cylindrospermopsin (Baker 1998). The nearby riverine site of Woodleigh had algal concentrations less than one-tenth of those recorded in Moura Weir (Fig. 5.2). However, the timing of the mid-December increase in cell numbers was similar at both sites.

Volumes of inflows into Moura Weir, just downstream from Woodleigh were critical in determining the phytoplankton population. Flows of approximately 1000 ML day^{-1} were recorded prior to the cyanoprokaryote bloom in Moura Weir, whereas flows greater than 10000 ML day^{-1} produced a rapid decrease in algal numbers after 10th February 1998 (Fig. 5.2). Although outflow volume and residence time were not available for the weir, depth sampling profiles (Fig. 5.3) show that the smaller volume inflows of approximately 1000 ML day^{-1} were retained within the weirpool until 1st December 1997, by which time the impoundment had filled.

Other key factors prior to and during bloom formation (Fig. 5.3) were similar to those identified by Fabbro and Duivenvoorden (1996). These included an increase in the temperature of waters above the sediment water interface as flows entered the weirpool, inflows into a waterbody whose deeper waters were low in oxygen, potential for increase in available nutrients as a result of inflows and/or deeper mixing, increase in water clarity and high pH of the water (greater than 8.1) during the period of the bloom. The corresponding ratios of mixing depth to euphotic depth during the period of increased concentrations of *Cylindrospermopsis* are also very similar to those recorded in the lower Fitzroy River by the above authors.

This is not the first occasion of a cyanoprokaryote bloom occurring as sediment load decreased in Moura Weir. A similar scenario, which resulted in a bloom of the cyanoprokaryote *Anabaena torulosa* was recorded in Moura Weir in late 1994 (Johnstone *et al.* 1995). The central issue here is that once light no longer limits algal growth, it is those algae which are adapted to living in low light conditions (eg. the cyanoprokaryotes such as *Cylindrospermopsis* and to a lesser extent *Anabaena*) that succeed due to high temperature and system generated availability of nutrients (especially phosphorus) in forms suitable for their growth. Results from nutrient samples taken so as to provide an integrated result over the entire water column show elevated concentrations of filterable reactive phosphorus and ammonium nitrogen (Fig. 5.4). Concentrations of total nitrogen (TN) and total phosphorus (TP) exceed those recommended in the Draft ANZECC (1999) guidelines (see Chapter 4). Algae can flourish in systems recording such elevated nutrient concentrations, especially those of phosphorus. These nutrients are often lost from the land to the river initially attached to sediment particles.

The detection of a potentially toxic cyanoprokaryote bloom in Moura Weir is not the only concern raised by the data. Another is the low oxygen concentratins in Moura Weir both in the well-mixed water column and in the hypolimnion during periods of stratification, shown by the darker coloured areas in Figure 5.3 (d). Deficiencies in oxygen concentration may ultimately be reflected in the depauperate fish and macroinvertebrate populations. As oxygen is produced by photosynthesis and anoxia contributed to by the oxygen demand of degrading material above the sediments, the paucity of photosynthetic algae for much of the year is of concern. An anoxic hypolimnion also produces conditions that enhance the release of soluble forms of nutrients and ultimately increases the potential for algal blooms.

Although reduced phytoplankton concentrations coincide with increased sediment load and decreased light penetration into the water column, they may also be influenced by the presence of herbicides e.g. atrazine. Such herbicides were repeatedly detected at most sites along the Dawson River during this study (Chapter 4) and at many sites within the Fitzroy River catchment during an earlier study (Noble *et al.* 1997). The precise exposure of algal populations to such chemicals is unknown. However, the phytoplankton populations in both Moura Weir and Woodleigh showed the following characteristics:

- .Depauperate phytoplankton populations particularly during flow periods when herbicides are transported into the water column.
- Low concentrations of green algae (chlorophytes).
- Dominance of reduced populations of phytoplankton by *Cryptomonas.* These organisms have a gullet and can survive heterotrophically when photosynthesis is not possible in turbid conditions or when the photosynthetic apparatus of other eukaryotic algae has been rendered inoperative by herbicides eg. atrazine.
- Dominance of increased phytoplankton concentrations of cyanoprokaryotes by *Cylindrospermopsis*, a genus of algae closely related to *Cylindrospermum.*

These characteristics of the phytoplankton population are consistent with those produced in experimental studies to investigate the effects of the herbicide atrazine on phytoplankton communities (Hamilton *et al.* 1988). Future studies need to target an increased understanding of the precise effects of herbicides on the phytoplankton of this river system.

Upper Dawson Sites

Unfortunately, safety and logistic problems prevented sampling through the summer period with the greatest probability of bloom formation. In the reduced sampling period an algal bloom was not detected at the Upper Dawson River sampling sites (Fig. 5.4). However, there is some indication of potential for increase in algal numbers at Orange Creek and Glebe Weirs. It should also be noted that between August and November, Orange Creek Weir had higher phytoplankton cell densities than Moura Weir, Woodleigh and the other upper Dawson sites sampled at this time (*cf.* Figs 5.2c & 5.5).

Potentially toxigenic/toxic cyanoprokaryotes

Strains of *Cylindrospermopsis raciborskii* and *Microcystis aeruginosa* from the Fitzroy River catchment are known to produce toxins. *Cylindrospermiopsis. raciborskii* was detected in samples from Moura Weir and Orange Creek Weir whereas *M. aeruginosa* was identified from Theodore Weir. Samples of the cyanobacterium *Plectonema wollei* (*Lyngbya wollei*) were detected at Roma Road. Samples of this species from Florida have been found to contain neurotoxins. *Plectonema* is normally a benthic mat-forming cyanobacterium known to flourish in high iron and sulphur environments often provided by groundwater springs. The toxicity of Australian material has not as yet been assessed. If mats are detected during future samplings, toxicity testing is recommended.

CONCLUSIONS

In summary, a number of problems have been highlighted by this study. They include:

a. the potential for formation of toxic algal blooms and
b. deficiencies in the oxygen level of the water column even at times when the water column was flowing and not stratified.

High concentrations of suspended sediments transport nutrients from the land into the water column and require reduction by careful management of runoff. This is a key issue in terms of nutrient cycling in the water body and success of photosynthetic organisms. The high concentrations of available nutrients are the reason why there is rapid development of cyanoprokaryote blooms with increased penetration of light into the water column. Reduction in sediment loading over a period of time not only reduces nutrient inputs but also enhances the growth of macrophytes and these in turn compete with potentially harmful algae, oxygenate the water column and provide a habitat for invertebrates and fish.

Until sediment loads can be reduced and the above factors addressed in the longer term, the key issue for water usage is to predict and monitor the rise in numbers of potentially harmful algae in addition to adequately treating the water to be used by humans and animals alike. The information in this chapter in relation to the temperature and flow regimes which select for the increase of *Cylindrospermopsis* suggests that there should be increased monitoring at times when water improves and there should be an increased anticipation of problems during this time. Quality treatment of potable water supplies and community notification of problems via the media and water body signposts should be provided by local authorities or other relevant water managers. The fully functional Queensland Department of Natural Resources intensive monitoring and information system is also highly recommended as a directory to enable notification of algal problems and management advice. This information system can be accessed at Department of Natural Resources offices or through their website[2].

The issue of herbicides and their impact upon the microscopic plant life of this region requires detailed investigation in future projects. However, the issue of the presence of herbicides within the river system needs to be immediately addressed and concentrations reduced.

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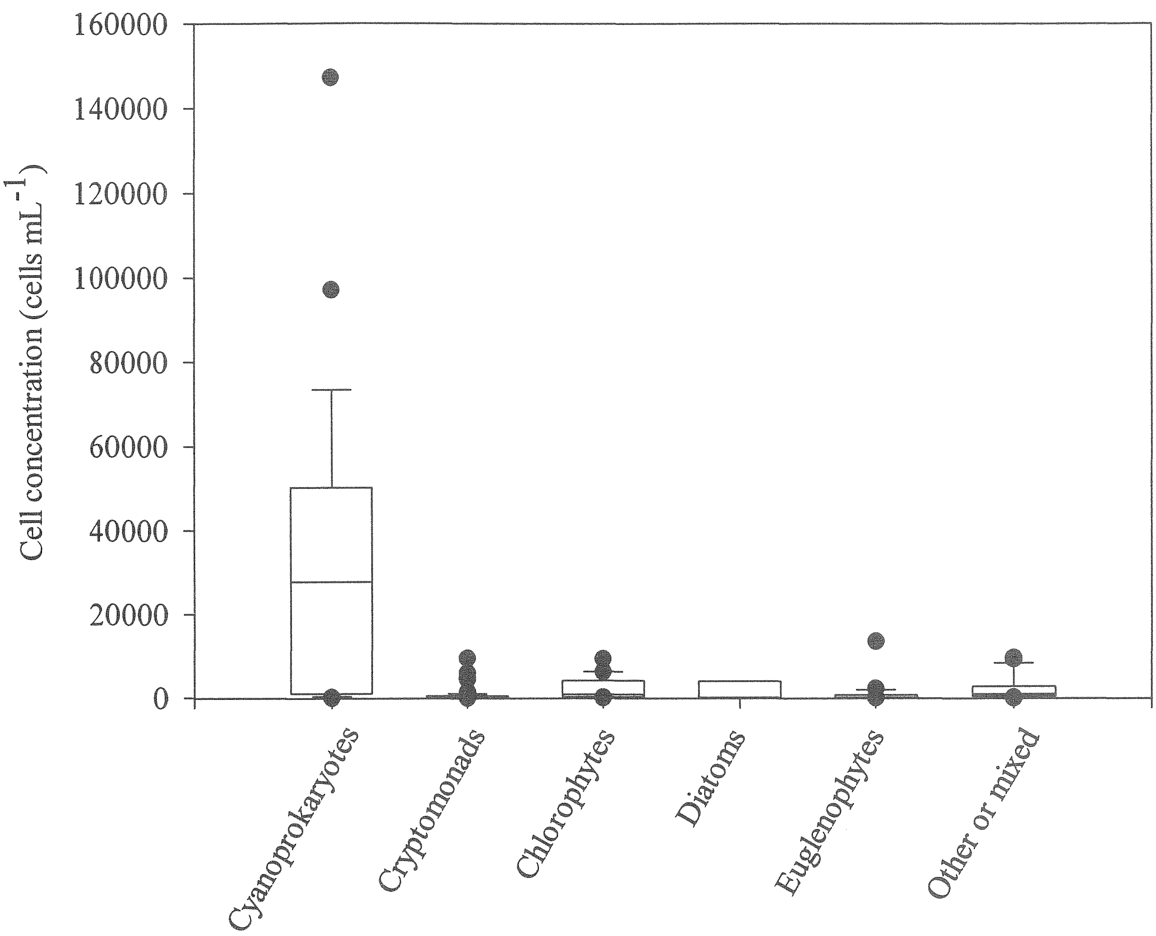

Fig. 5.1. Algal groups dominating the phytoplankton in comparison with the total phytoplankton cell concentration in the water column at the time of sampling. Data are derived from the population structure of all phytoplankton samples taken during this programme.

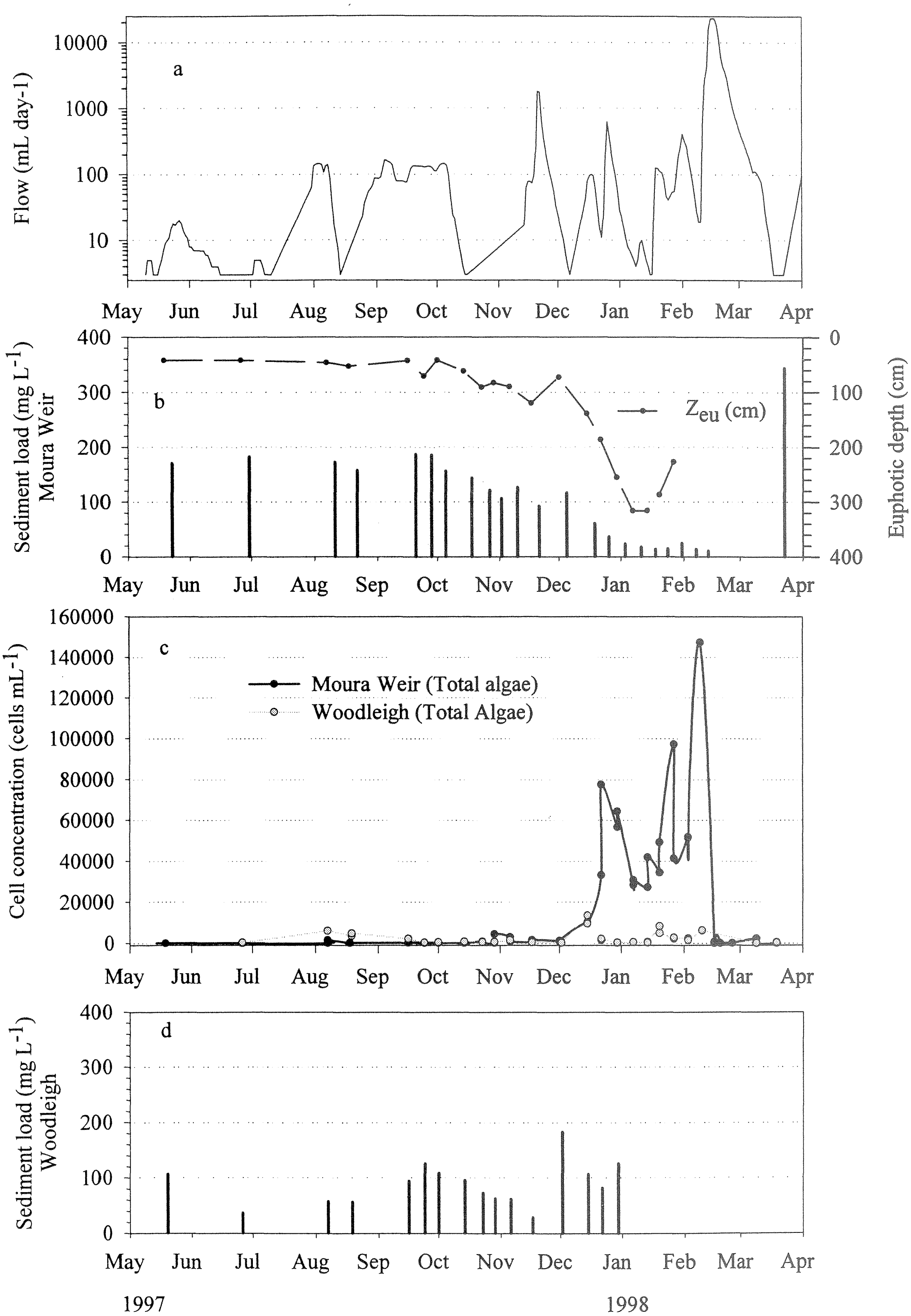

Fig. 5.2. Time series plots of (a) inflow into Moura Weir as estimated at Woodleigh; (b) sediment load and euphotic depth in Moura Weir; (c) total phytoplankton cell concentrations at Moura Weir and the unimpounded site of Woodleigh and (d) the sediment load at Woodleigh between May 1997 and April 1998.

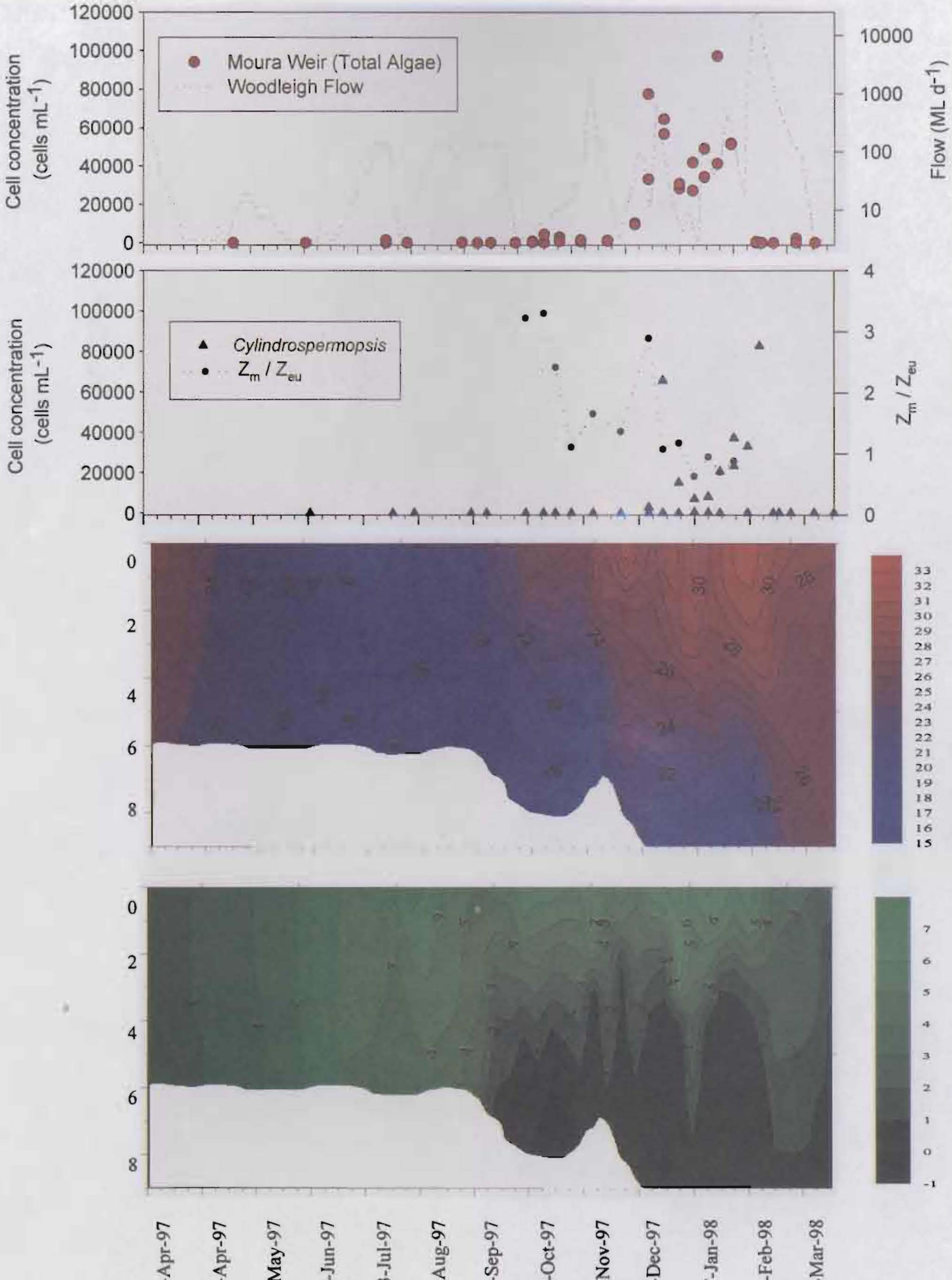

Fig. 5.3. (a) Phytoplankton cell concentration and inflow into Moura Weir; (b) the cell concentration of *Cylindrospermopsis raciborskii* and variation in the ratio of mixing depth to euphotic depth of the water column (Z_m / Z_{eu}); (c) isotherms and (d) isopleths of dissolved oxygen concentration in Moura Weir between 2 April 1997 and 27 January 1998.

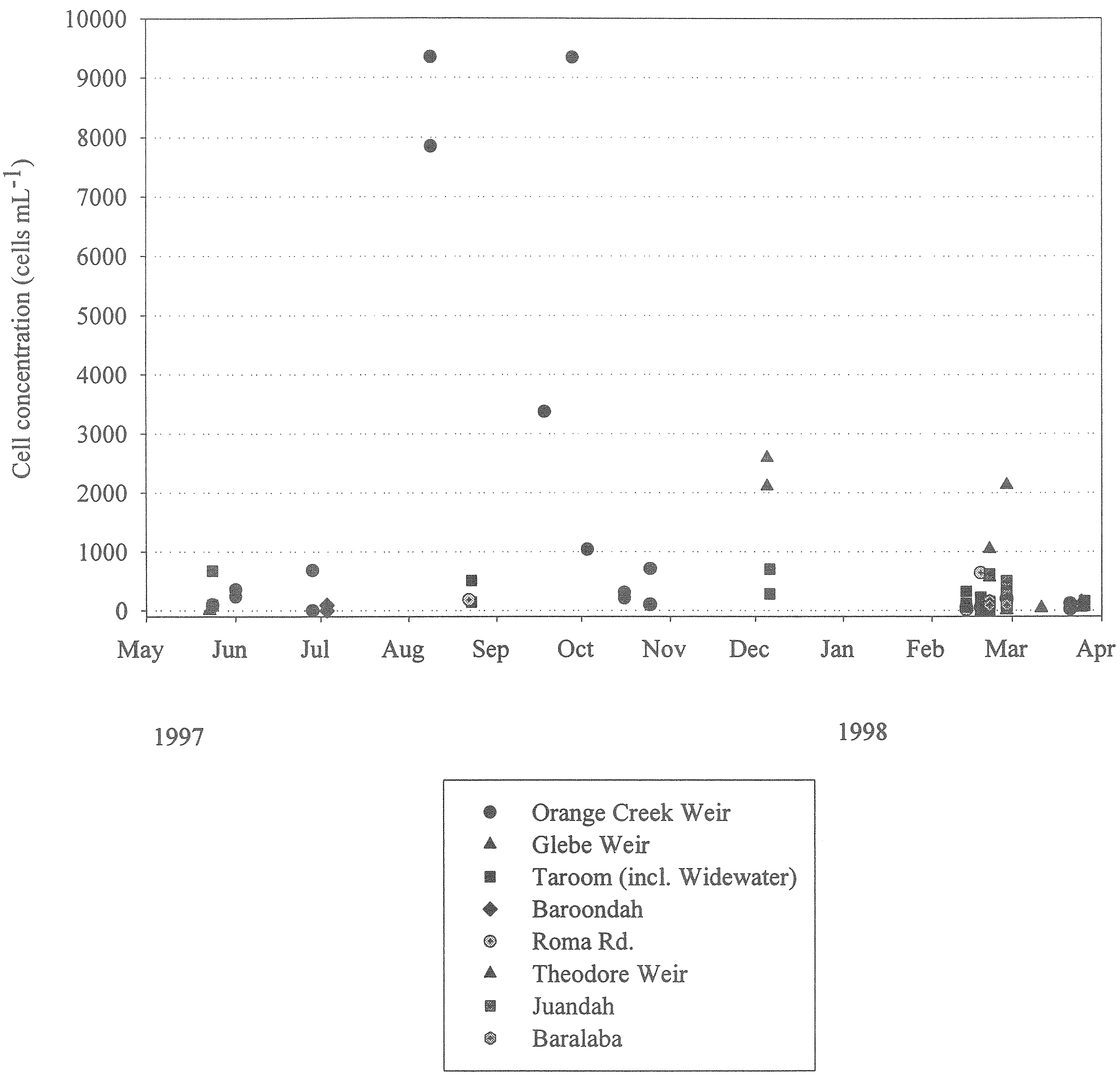

Fig. 5.4. Phytoplankton cell concentration at upper Dawon River sites.

6. Temporal Variation of Macroinvertebrate Communities of Impounded and Riverine Sites in Central Queensland

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INTRODUCTION.

Aquatic macroinvertebrates have extremely important roles in the functioning of aquatic systems and have many features that make them suitable as indicators of the condition of these systems. For these reasons and others they are now widely used throughout Australia in the assessment of the 'condition' of freshwater aquatic systems. They are a diverse group of animals, occupying a large range of niches, and they have pivotal roles in nutrient recycling because they feed on the algae, plants and dead organic matter (eg leaves) in streams. They are an important source of food for fish, birds and other organisms associated with waterways. Benthic (bottom dwelling) macroinvertebrates are useful indicators of the 'health' of aquatic systems because their close association with bottom sediments places them in contact with many pollutants that are adsorbed onto the particles that settle on the streambed. A varying range of sensitivity to pollution adds to their value as indicator organisms as some taxa exhibit sensitivity to particular groups of pollutants (eg. heavy metals) while others show a degree of tolerance. Thus, the disappearance of more sensitive taxa and increased abundance of tolerant species can be a useful guide, not only to the presence of pollution or disturbance, but to the type of pollutant present. Due to their relatively sedentary nature, their population can be used to detect spatial variations in the condition of aquatic systems, helping to detect sources of local disturbances to stream ecosystems. Macroinvertebrates also have the advantage that they can be collected, stored and transported in large numbers with the use of simple equipment (Chessman, 1995).

Previous broad scale studies of aquatic macroinvertebrates in Central Queensland between 1993 and 1996 revealed that the health of most sites studied was good (Duivenvoorden & Roberts, 1997), though information on temporal variation was limited to only two sampling periods per year. More information on intra-annual variation on macroinvertebrates communities is of interest given the changes that may occur as a result of flow events or seasonal application of pesticides. Knowledge of these changes improves our understanding of the system which should lead to improved management practices. In regulated streams of the region there is also an absence of information on the impact of river impoundment on these communities, which is also important to river management. River impoundment is necessary to provide water for irrigation, among other land use practices. This has several hydrologic impacts, including reducing the frequency of low flows and minor floods, whereas water quality parameters, such as dissolved oxygen and temperature, seem to be unaffected by impoundments except in extremely low flow events (Sheldon and Walker 1997). Other effects of impoundment may include alteration of food webs and sedimentation patterns (Naselli-Flores and Barone 1997) often due to the physical barrier nature of the impoundment and its alterations to regular inflows.

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Such changes to the physical nature of the system have had a large impact on macroinvertebrate distribution in other areas (Rossaro and Pietrangelo 1993 & see also Byrne 1998; Snaddon and Davies 1998; Sheldon and Walker 1997; Shrivastava and Desai 1997; Munn and Brusven 1991). These range from changes in the species composition of communities, to reduced diversity and abundance of particular groups of macroinvertebrates or the community as a whole. A notable exception is the study be Harding (1992) who did not find any significant differences between macroinvertebrates of impounded and riverine sites. Most of these studies have not been reported for the tropical regions of Australia where ecological processes may be different. The aims of the present study were to determine whether there were seasonal changes in macrobenthic communities in Cental Queensland and to compare the communities of impounded and riverine stream sites.

METHODS.

The Dawson River was chosen for study because it presented a suitable range of riverine and impounded reaches that were relatively easy to access. Two pairs of sites (each consisting of an impounded site and a riverine site upstream of it) were selected as representative of these reaches and sampled at approximately three monthly intervals between August 1997 and March 1999. The study was co-ordinated with the other studies of the chemistry, algae and fisheries of the system as reported in other chapters of this report to maximise opportunities of understanding the functioning of the aquatic ecosystem on an holistic basis. The upstream pair of sites consisted of a riverine site at Widewater just downstream of Taroom and a site on Glebe weir (Sites 7&6 respectively, Map 1). The other pair of sites was the riverine site at Woodleigh (Site 3) and Moura Weir (Site 2).

Initially, four two minute macroinvertebrate samples were taken at each site, but this was changed from 1998 onwards when data showed that six samples were required to obtain 98% of the taxa present (Fig. 6.1). This also allowed for a more accurate estimation of the mean number of taxa per site. Thus, from 1998, six two-minute samples were taken with a pond net (0.3 x 0.9mm mesh size), preserved in 100% ethanol and taken back to the laboratory for sorting and identification to family level. During collections, only the edge habitat was sampled.

Samples were sorted until at least 300 invertebrates were collected from each sample. In all cases, a minimum 10% of the sample was sorted regardless of numbers found in order to reduce the likelihood of not sampling rare taxa (Marsh, 1997). Microcrustacea (eg. copepods and Ostracods) were not recorded. Statistical tests, including a one way analysis of variance (ANOVA), an all pairwise multiple comparison procedure (Student-Newman-Keuls method) and cluster analysis (using group average linking of Bray-Curtis similarities on presence/absence data) were used to determine differences and similarities between sites based on invertebrate richness and composition data.

Flow data was provided by I. Wallace of DNR and was converted from cubic metres per second ($m^3 s^{-1}$) to megalitres per day (Ml day^{-1}). Physical and chemical data including pH, Dissolved Oxygen (DO) and Electrical Conductivity (EC) were measured and provided by N. Kelly of DNR.

RESULTS

A total of 86 taxa were recorded from the four sites over the duration of the study. This is higher than the 70 taxa recorded during the previous study of the entire Fitzroy catchment from1993-96 (Duivenvoorden and Roberts 1997). In comparison, studies carried out in the central and northwest regions of New South Wales found a total of 86 taxa at 43 sites surveyed on three sampling occasions (Brooks 1998).

Temporal variation in the total number of taxa per site was high (Fig. 6.2) and analysis of variance showed there were significant differences over time (though none of these was obviously related to season). Further analysis of this variation showed that only two of the more dramatic decreases in the number of taxa were statistically significant; the first between August and December 1997 at Woodleigh and the second between December 1997 and February 1998 at Moura Weir (Fig. 6.2). The first of these was associated with a flow of about 1600ML/day that occurred 9 days prior to the December 1997 sampling at Woodleigh ('1' on Fig. 6.3). The second decrease was associated with a complete absence of flow over the weir for almost three months prior to the February 1998 sampling ('2' on Fig. 6.3). Three other large reductions in richness at the remaining sites can also be linked to fluctuations in flow, however comparison tests showed these reductions to be insignificant ($P>0.05$).

Analysis of variance of the taxon richness data and multiple comparison tests showed there was a significant difference between the impounded and riverine sites. Impounded sites were significantly lower in richness than their upstream riverine sites (Table 6.1). The lowest average richness over the study period was recorded at Glebe Weir with 9.9 taxa, while richness at Moura Weir averaged 10.2. Analysis showed there were no significant differences in the number of taxa between these Weirs. A similar result was recorded when the riverine sites Widewater and Woodleigh were compared (Table 6.1).

Table 6.1: Results of All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) Comparisons for factor

Comparison	Difference of Means	p	q	P<0.05
Widewater vs. Glebe Weir	5.526	4	8.038	Yes
Widewater vs. Moura Weir	5.158	3	7.503	Yes
Widewater vs. Woodleigh	1.105	2	1.608	No
Woodleigh vs. Glebe Weir	4.421	3	6.431	Yes
Woodleigh vs. Moura Weir	4.053	2	5.895	Yes
Moura Weir vs. Glebe Weir	0.368	2	0.536	No

Cluster analysis clearly grouped the riverine and impounded sites separately (possibly in part due to the lower taxon richness at the impounded sites) (Fig. 6.4). Generally communities at Glebe Weir and Widewater each formed a large distinct group, while communities at Moura and Woodleigh formed several clusters with some communities similar to those at Glebe and Widewater. Glebe Weir formed a large distinct cluster, however two sub clusters could be found within this larger grouping. The smaller of these two clusters is distinct at 56% similarity and includes the November 1998 and March 1999 samples, indicating a change in the macroinvertebrate community between August and November 1998 possibly as a result of the large flows during this time. (A similar change occurred in the phytoplankton populations over this period as discussed in Chapter 5 of this report).

Average invertebrate abundance ranged greatly over the duration of the study, from as low as nine to over 800 animals per sample (Fig. 6.5). The impounded sites tended to have lower abundance than the riverine sites and numbers were generally lower during the first half of the study. Widewater (the most upstream site) had the highest macroinvertebtrate abundance on most occasions. The most abundant taxa were the Hemiptera, Gastropoda, Diptera and Decapoda.

Many of the fluctuations in abundance were due to large increases in the population of one taxon. The large increases seen at Widewater and Moura Weir between November 1998 are good examples of this. In the case of Widewater, Gastropod populations were very high in November 1998 and March 1999 (accounting for approximately 80% of abundance). Hemipteran numbers were extremely high at Moura Weir in August 1998 (over 70% of abundance).

Numbers of pollution-sensitive taxa (Ephemeroptera and Trichoptera) were generally lower at impounded versus riverine sites, though at least some of these taxa were present at all sites on all sampling occasions (Fig. 6.6). At Glebe Weir there was a trend for numbers of sensitive taxa to increase from June 1998 onwards, which mirrored an increase in abundance of invertebrates over this period at this site (Fig. 6.5).

DISCUSSION

Results of this study show that macroinvertebrate populations of sites in impounded reaches have fewer taxa, appear to be generally lower in abundance and tend to have lower numbers of pollution sensitive taxa than populations at riverine sites. More rapid and more extreme water level fluctuations may be a key factor in explaining the differences as food sources and habitats are lost or altered as the water level fluctuates. These effects have been recorded by other authors (Palomaki 1994; Shrivastava and Desai 1997) and include the loss of aquatic macrophyte populations (Naselli-Flores and Barone 1997) used as habitats for macroinvertebtrates. Of note is that submerged aquatic vegetation was not present at any of the sites studied in this investigation – probably as a result of water level fluctuations and high turbidity and possibly herbicide contamination. Moura Weir in particular showed a high degree of variation of its macroinvertebrate composition communities from sample date to sample date. This was evident in the cluster analysis of this site for which a distinct group did not form (Figure 4). Invertebrate communities are forced into changes, as niches become unavailable due to water level fluctuations resulting in a highly variable macroinvertebrate community. Lower taxon richness occurs as those taxa that cannot cope with sudden habitat changes die out (Munn and Brusven 1991).

Generally lower numbers of Ephemeropteran and Trichopteran taxa (known to be sensitive to pollutants) at both impounded sites suggests water quality may be contributing to the lower taxon richness. However studies by Camargo and de Jalon (1995) and Snaddon and Davies (1998) indicate that these taxa are particularly vulnerable to fluctuations in water levels leading to the conclusion that such fluctuations may be responsible for the lower taxon richness. It is also possible that the increased pressure on the impounded sites, through irrigation and consequences of other anthropogenic activities, such as pesticide runoff, contribute to lower invertebrate richness (Brooks 1998). However, sensitive taxa were always present, if only at low levels (Figure 6) showing that pollutants may not be a major factor, although this cannot be ruled out. Higher taxon richness and a tendency for higher numbers of sensitive taxa at the riverine sites suggest these sites are of comparatively higher water quality, possibly because they were subject to conditions more characteristic of those that occur naturally.

Two significant declines in invertebrate richness were observed at particular sites over time with major fluctuations in flow rates most likely responsible. The first significant decline, at Woodleigh between August and December 1997, most likely resulted from a wash out effect of the flow event that occurred 9 days prior to sampling in December. This has been recorded in other studies (Munn and Brusven 1991). In contrast the drop in richness at Glebe Weir from December 1997 to February 1998 may have been caused by the lack of flow for almost three months prior to the February sampling. The consequent drop in water level within the weir is likely to have reduced available habitat and resources for macroinvertebrates as discussed above. Oxygen and temperature regimes also become altered under such low flow conditions and this, too, may have had some effect on the populations (Sheldon and Walker 1997). As well as the direct physical effects of the flow events (eg. washing invertebrates away), secondary effects, such as removal and deposition of particulate organic matter, can affect the community by drastically altering food webs (Naselli-Flores and Barone 1997).

Temporal changes in invertebrate populations at the study sites also include changes in composition. Cluster analyses showed clearly that community structure at any one particular site and sampling occasion was generally distinct from that at other sites and sampling times (as replicate samples tended to group together). This illustrates that the communities change over time. Of interest was the finding that samples taken from the two upstream sites (Widewater and Glebe Weir) clustered as distinct groups. This points to a general consistency in the composition of the communities at these sites over time, and conversely, a more variable community composition at the two downstream sites. While differences in the magnitude and frequency of water level fluctuations in Moura as compared to Glebe Weir may partly explain the more dynamic changes in the former over time, they are less likely to account for the more variable composition of communities over time at Woodleigh. We speculate that the latter may be accounted for by a higher degree of 'disturbance' from irrigation flows at this site as compared to flows at Widewater. Disturbances of this nature have also been implicated in effects on macroinvertebrate populations in other studies (Snaddon and Davies 1998) and more information is required on the rate of recovery from such disturbances. The mechanism by which such disturbances might affect the communities could be through changes in sedimentation rates and processes and effects on nutrient cycling, light penetration and microbial processes. These together may strongly influence the availability of both detrital and photosynthetically derived food sources for macroinvertebrates. Pesticides entering the river from the irrigation areas located downstream of Widewater and Glebe Weir may also have had some effect on the macroinvertebrate communities at the Woodleigh and Moura Weir sites. Concerns about pesticide effects on macroinvertebrates and river health have also been reported for irrigation areas in northern New South Wales, particularly in relation to the insecticide endosulphan (Brooks 1998). Further research is required to isolate the effects of water level fluctuations and other factors such as pesticides on the macroinvertebrates and general river health in the Fitzroy catchment.

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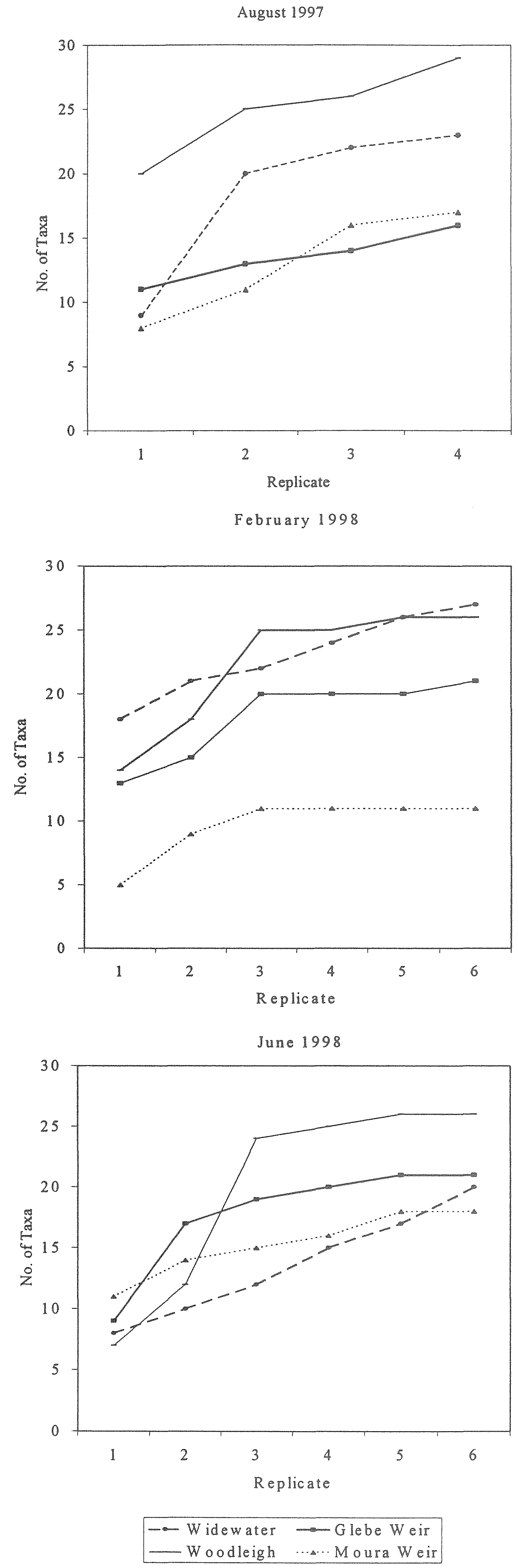

Figure 6.1 Cumulative increase in the number of new taxa per replicate, from August 1997, February & June 1998.

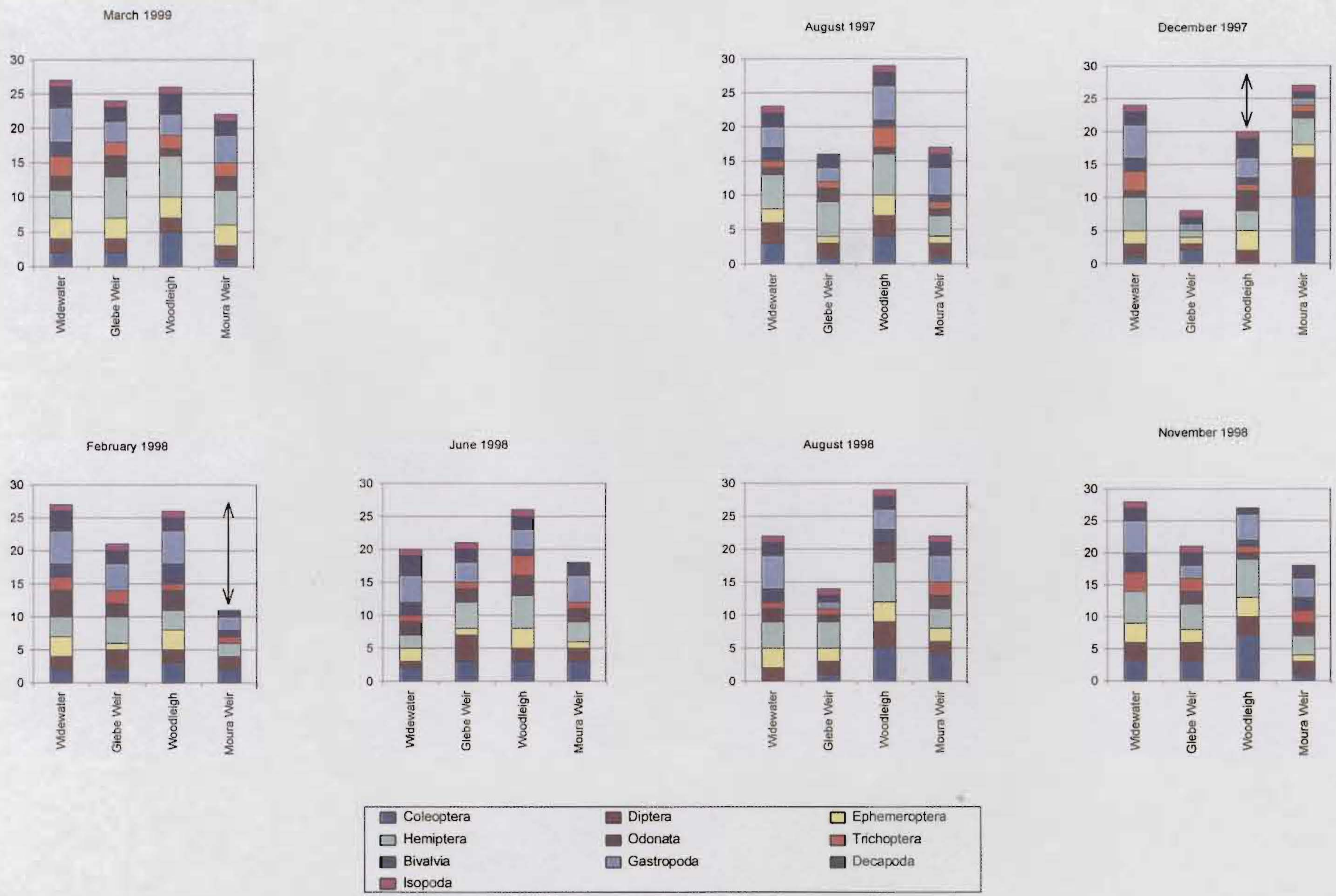

Figure 6.2 Total number of macroinvertebrate taxa per site from August 1997 to May 1999.

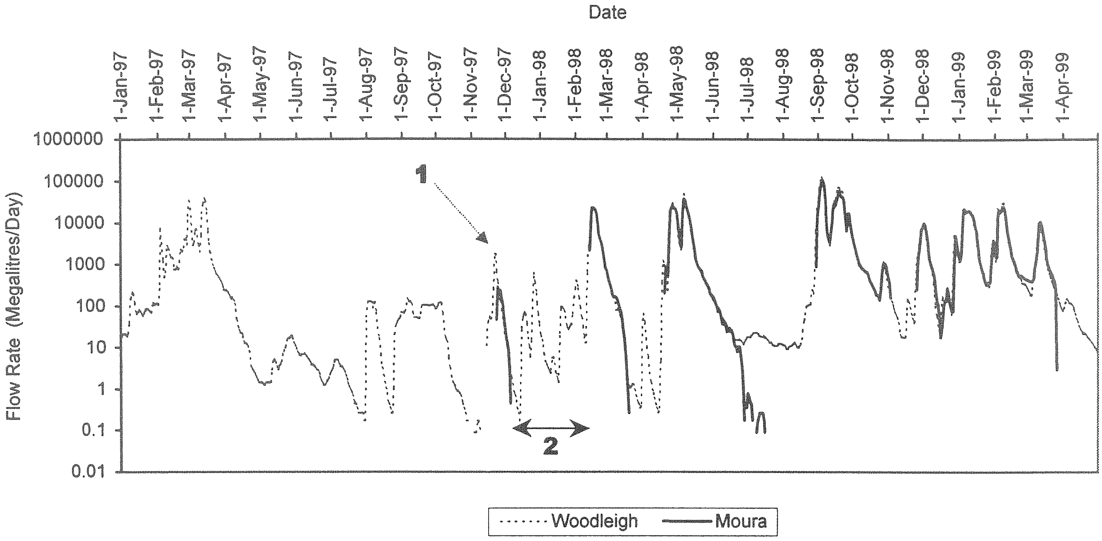

Figure 6.3 Flow rates at Woodleigh and Moura Weir, from January 1997 to April 1999.

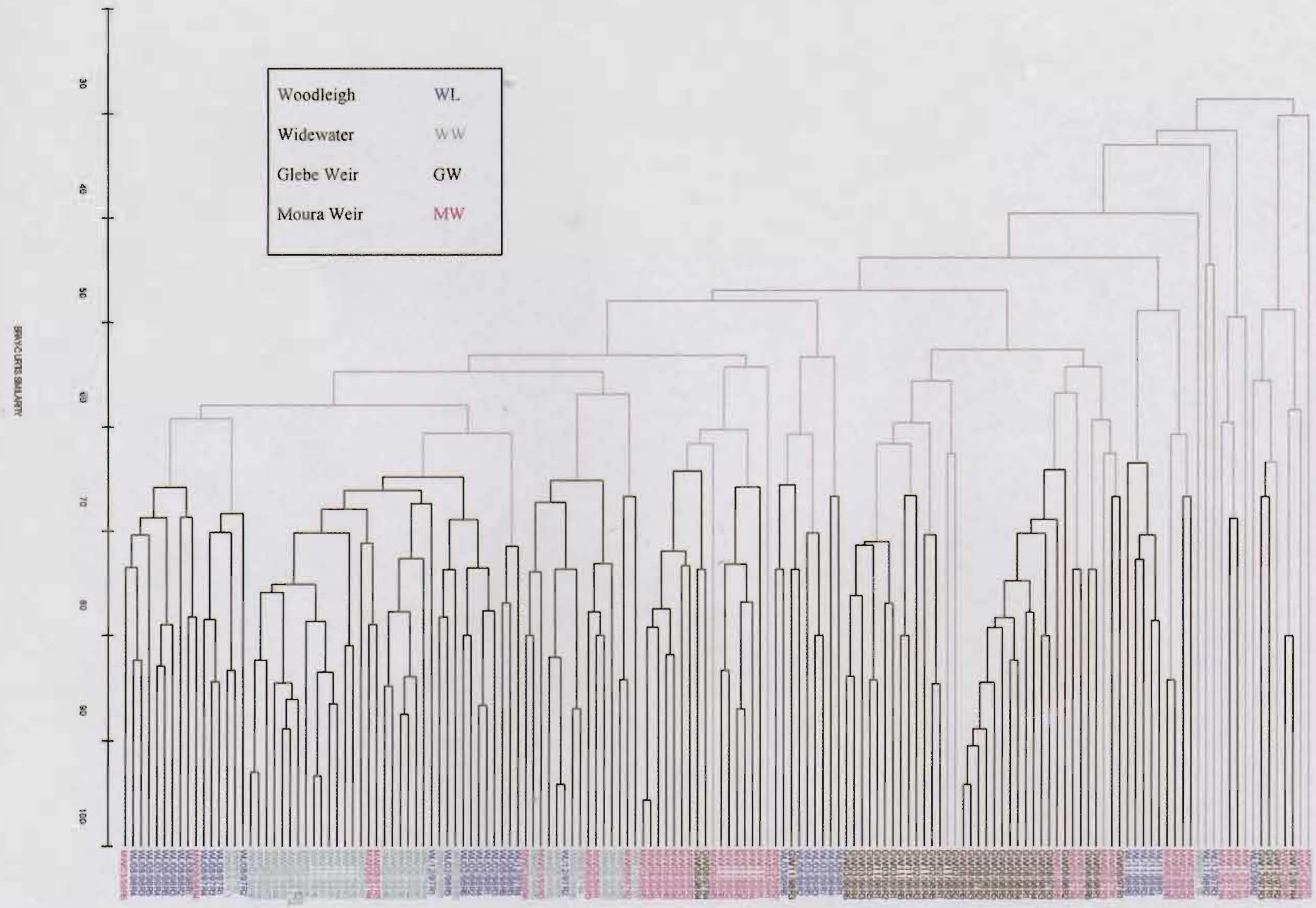

Figure 6.4 Dendrogram for hierarchical agglomerative clustering of 152 replicates, comparing 4 sites using group average linking of bray-curtis similarities calculated on species richness data.

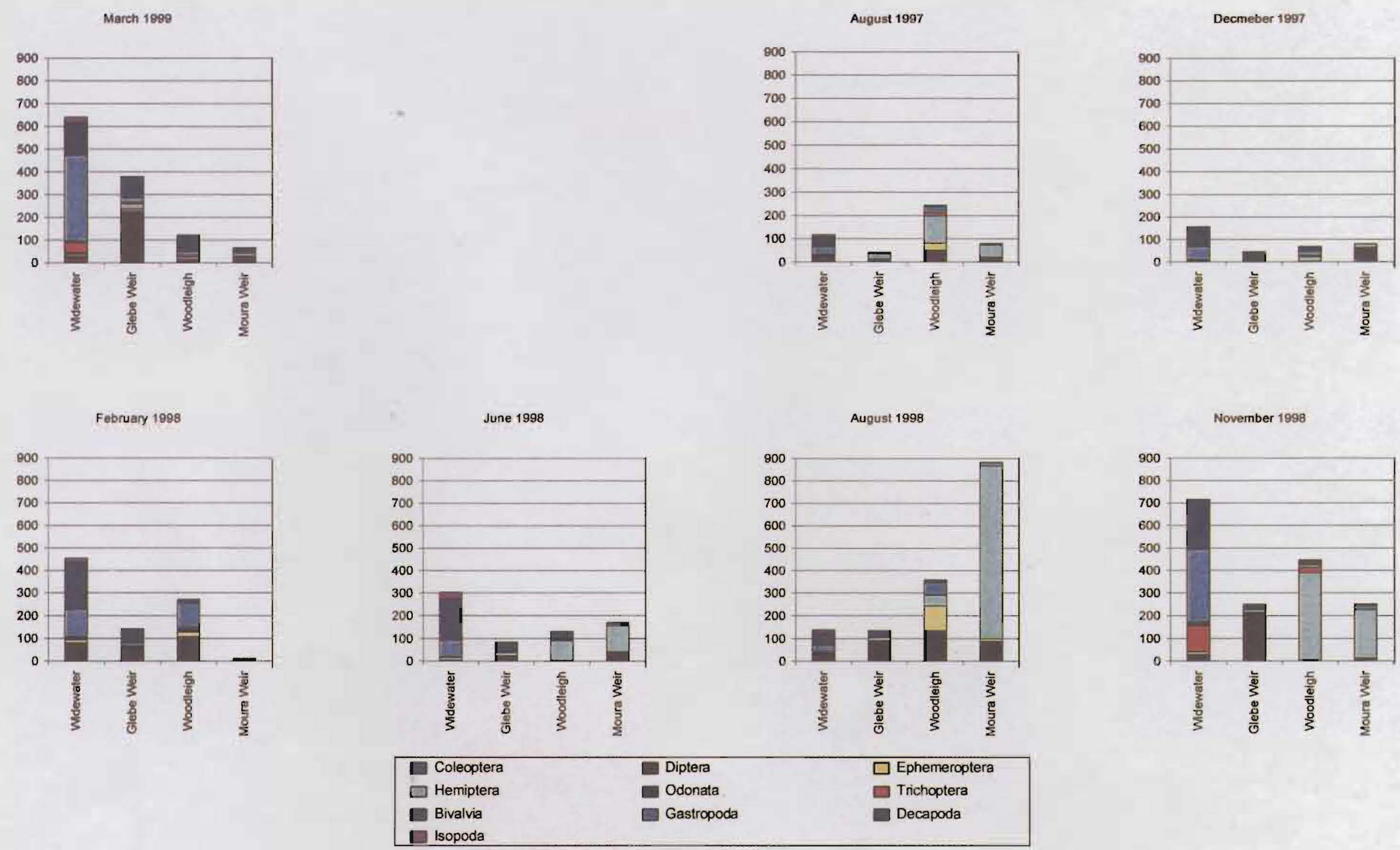

Figure 6.5 Average abundance of taxa per sample at four sites, from August 1997 to May 1999.

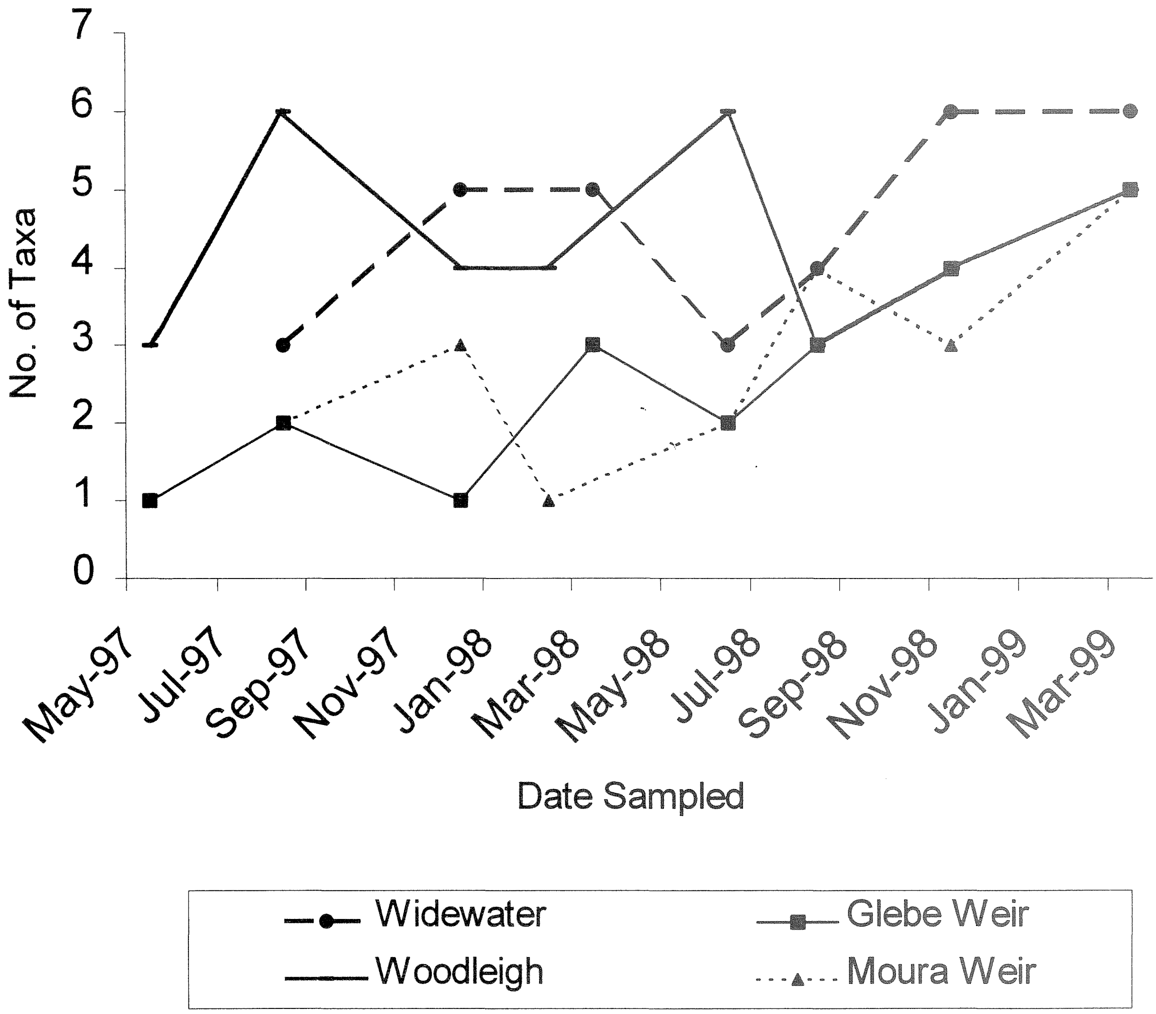

Figure 6.6 Total number of sensitive taxa (Ephemeroptera and Trichoptera), Per Site, from May 1997 to May 1999.

7. Fish Communities in the Dawson River – Weir and Riverine Environments.

P. E. Long[1].

SUMMARY

This fisheries study is a component of the National Heritage Trust (NHT) supported *Water Quality in the Fitzroy Catchment Project* with the results complimenting the range of physico-chemical and biological data collected. This section reports on the two-year fisheries component that undertook work at four sites in the mid and upper sections of the Dawson sub-basin.

Sampling was undertaken quarterly using a range of fisheries apparatus. A total of 4024 fish were recorded from 19 species of 13 families, two of which were exotic. The results compared favourably with similar semi-arid catchments of sub-tropical Australia. Species numbers declined further up the catchment in line with trends established in other Australian rivers (Lake 1982; Pusey *et al.* 1993; Berghuis & Long 1999). Fish species present in the catchment have evolved to cope with the ephemeral nature of the system, with many species responding to this cycle of drought and flood by opportunistic migration, spawning and rearing strategies. One species, bony bream, one of Australia's few herbivorous fish dominated gill net captures at all sites.

Habitat type, physico-chemical water quality data and waterbody descriptions were assessed. This is the first comprehensive replicated fisheries sampling conducted in the Dawson sub-basin. The data compiled during the project is reflective of other baseline fisheries studies conducted within the Fitzroy Catchment (Midgley 1979; Berghuis & Long 1999).

INTRODUCTION

Fish are the most visible and well known of our aquatic biota, with the general community knowing which species are present and some understanding of populations. Many people use this knowledge to assess the status of stream "health". It is now broadly accepted that we need to maintain fish communities in as natural a state as possible. However to maintain these communities we require knowledge of the status and trend of our fisheries resources and their relationships to other stream biota, water quality and in-stream and riparian habitat parameters. This knowledge can then be used to better manage our catchment and stream environments and the impacts upon them.

In Queensland we have a very low level of knowledge of our freshwater fisheries resources and accordingly a limited understanding, especially within the Fitzroy Catchment. There have only been two previously documented fisheries studies conducted on the Fitzroy River Catchment (Berghuis & Long 1999; Midgley 1979). Midgley sampled at twenty-one localities and captured twenty-four fish species.

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Berghuis & Long's three-year study of twenty-one different sites reported twenty-six fish species. This later project was the first replicated fisheries study of the Dawson River and provided base-line data to assess the current status of this sub-basin and compare future trends. Two recent fishway research projects in the lower Fitzroy River have added to the fisheries knowledge of the Catchment (Stuart & Berghuis 1997; Stuart 1999).

The Dawson is a sub-basin of the Fitzroy Catchment in the Northeast Coast Drainage (Merrick & Schmida 1984). It has a diverse fish community and complex species-habitat relationships. Due to the nature of its geographic location it is home to fish species of both temperate and tropical origins. Freshwater fish species numbers (on a catchment basis) generally increase as latitude decreases (Merrick & Schmida 1984).

The Dawson River sub-basin covers an area of 50,830 km^2 and is the most southern of six sub-basins of the Fitzroy Catchment. The Dawson sub-basin provides some 14% of the Fitzroy Catchment mean annual discharge of 5,500,000 megalitres (Baxter 1992).

Commencing in 1929, six weirs have been constructed along the Dawson River. At full supply level the weirs have pooled water along 58% of the regulated section of the Dawson River channel bed (Anderson & Howland 1997). Given that the Dawson River has a very low uniform gradient (Long 1992), this has modified the stream environment by removing a proportionally high percentage of ripple and run areas which are critical habitats for many fish species.

The Dawson sub-basin was selected for this project due to its diversified land use patterns, including grazing, dry land cropping and irrigation cropping. The 1993-1996 project *Downstream Effects of Land Use in the Fitzroy Catchment* (Noble *et al.* 1997) provided baseline information consisting of biological and physico-chemical data on the Dawson sub-basin. This provided an opportunity to quantify differences in the fish community between impounded (weir) and riverine sites.

Aims of Fisheries Component

As one component of this multi-faceted project, the fisheries study was designed to compliment data collected by other groups involved in the project. The primary purpose of the fisheries study was to gain an understanding of the nature of fish communities in impounded (weir) and riverine sites of the Dawson River on a seasonal basis. In collecting and interpreting fisheries data, management agencies have the ability to implement more soundly based options for water infrastructure and environmental flow provisions.

METHODS

Study Sites

Fish were sampled at four sites in the Dawson sub-basin, on eight occasions from May 1997 through to March 1999. The four sites were divided into two paired sites, each consisting of a riverine and weir habitat (Fig. 7.1). The upper sub-basin sites (Long & Berghuis, 1995) were Glebe Weir (Site 6, Map 1) and Widewater (Site 7, Map 1) while the mid sub-basin sites were Moura Weir (Site 2, Map 1) and Woodleigh (Site 3, Map 1). In both paired sites the riverine site was upstream from the weir pool. Adjacent landuse patterns differ in that sites 6 and 7 are influenced by beef cattle grazing and dryland cropping activities, while sites 2 and 3 were additionally influenced by intensive irrigation cropping on the flood plain (Noble *et al.* 1997). A detailed description of sites is provided at the end of this chapter.

Apparatus and Sampling Methods

The principle sampling apparatus employed during the study was a nylon monofilament sinking panel gill net. Six of these were used; they were 15 metres long with a 2.2 metre drop, each consisting of 3 x 5 metre panels of 50 mm, 100 mm and 150 mm meshes arranged in that order. The nets were utilised in three pairs. All gill nets were deployed at 90° to the waterbody bank. One pair of nets was set from each bank, one net with the largest mesh to the bank, the other with the smallest mesh to the bank. A further two nets were set 15 metres from each bank with the meshes in opposite combination to each other. These sets enabled fish to be captured either in the centre of the waterbody or along the bank. All nets were set 2.5 hours before official sunset (as determined by *Garmin GPS 45*), cleared just prior to sunset during the summer and autumn surveys and retrieved 2 hours after sunset. This period, before and after sunset, generally coincides with an increase in fish movement activity stimulated by feeding behaviour.

Additional sampling included fyke nets and baited traps. Four fyke nets were used at each site. The fyke nets were of traditional design consisting of seven metal rings, the first ring having a horizontal diameter of 670 mm with the others graduating down in size towards the end. A single wing of 5.8 metres in length extends from the first ring. Covering material was woven nylon of a 30 mm mesh size. The fyke nets were placed adjacent to each bank with the opening facing downstream.

Eight baited fish/crustacean traps with dimensions of 0.25 m x 0.25 m and a length of 0.45 m with covering mesh of 3 mm aperture were baited with dog biscuits and set for a total of 4 hours before sunset and checked and cleared at two hour intervals. Trap sites were selected to cover the representative habitat types within the site at a depth of 0.5 metres of water or less. All equipment was set in the same position throughout the project, with all net sites marked for return occurrences.

Capture Techniques

Fyke and gill nets are both interception nets. They rely on fish moving within the waterbody for them to work effectively. Gill nets capture fish by entanglement, while fyke nets entrap fish in a pocket at the end of the trap. A fyke net works best when there is a flow in the waterbody. The open end of the net is placed facing downstream and the wing extended out at an angle to the opening.

The traps used were a rectangular prism with a funnel entrance at each end. The bait is suspended from a pouch in the top of the trap. The fish enter the trap in search of the bait and have difficulty finding the relatively small exit provided through the funnel.

Traps regularly capture fish up to 100 mm in length, either mature small species or immature specimens of larger species.

Water Quality

Water quality data was collected at all sites on all sampling occasions. The equipment used to collect this data was a *TPS® 90FL* water quality metre configured to record dissolved oxygen, water temperature, pH and conductivity. This data was supplemented with a measurement of turbidity using a Secchi disc. At each site the water quality measurements were taken in the middle of the water body and each parameter recorded at the surface and then at 1 metre intervals down to a maximum of 9 metres where possible.

As part of the habitat description documented for each site, a river cross section was recorded. This was achieved by recording the depth of the river at 3m intervals using a *Hummingbird LCR 4.ID* fish finder. Water body cross-section profiles are presented in Appendix B.

Fish Identification

The majority of fish captured were identified to species level in the field and released alive. Any fish specimens of dubious identity or unusual range were kept for further identification in the laboratory and/or sent to the Queensland Museum for identification. Keys used to identify fish species in the laboratory were those of Allen (1989) and Merrick & Schmida (1984). All fish kept were anaesthetised in a solution of benzocaine and preserved in 70% alcohol.

Sampling Timing

The four sites were sampled on contiguous days, quarterly each year for two years of the project (Figure 7.1). Two alterations to this were made due to flood events that made sampling impossible, with the sampling postponed until 4 – 6 weeks after the flood event. On one occasion there was a split round of sampling.

RESULTS

Water Quality

Five physico-chemical parameters (dissolved oxygen, pH, temperature, conductivity and turbidity) were recorded at each site. Dissolved oxygen levels at the surface varied from 49.6 to 129.8 % saturation. Large variations were noted between seasons and sites. Below a depth of 2 metres the level of dissolved oxygen commonly dropped considerably, often below levels that could sustain fish populations. The implications are that at certain times of the year where little mixing of the water column occurs a significant portion of the water body will not support fish, significantly reducing habitat available.

Readings at a depth of one meter for pH varied from 6.82 to 8.30 (Table 7.1). The pH was slightly acidic in the colder sampling periods and moved to the basic range in the warmer months. The conductivity ranged from 109 to 441 μS cm⁻1 with a mean of 204.4 μS cm⁻1. Both riverine sites always recorded slightly higher conductivity levels than the weirs, suggesting ongoing ground water intrusion. Turbidity was determined using a Secchi disc with results varying from 70 to 900 mm (Table 7.1). The turbidity obviously increased dramatically during flow events and was maintained at an elevated value many months after the flow.

Table 7.1: Water quality parameters

Parameter	Site	Range	Median*
Conductivity (μS/cm)#	Widewater	187 – 441	260
	Glebe Weir	127 – 220	178
	Woodleigh	164 – 317	233
	Moura Weir	113 – 273	188
pH#	Widewater	6.86 – 8.26	7.68
	Glebe Weir	6.82 – 7.95	7.50
	Woodleigh	6.82 – 8.30	7.45
	Moura Weir	7.22 – 8.21	7.31
Secchi Depth (cm)	Widewater	70 – 900	335
	Glebe Weir	70 – 170	98
	Woodleigh	100 – 750	205
	Moura Weir	90 – 730	115

at a depth of 1 metre
*the middle value in a data set when arranged in ascending order

The range of water temperatures varied across the sites and with each season. Temperatures recorded at one metre ranged from 15.0-22.5 °C in the autumn-winter sampling rounds to 26.1-34.2 °C in the spring-summer sampling rounds. This data is comparable with results of work reported in Noble *et al.* (1997) and Long & Berghuis (1995).

Fish species present

The Dawson sub-basin is unique in the context of freshwater fish communities in that it contains representatives of both tropical and temperate Australian species (Merrick & Schmida, 1984). Throughout the project 4024 fish were captured in both traps and nets. Whilst no new species were identified in the study the 19 fish species recorded (Table 7.2) represent a significant fish community for this section of the Dawson sub-basin. Anecdotal reports (Long & Berghuis, 1995) suggest that an additional four species were present in the Dawson sub-basin prior to the construction of the Fitzroy Barrage in 1970). They were barramundi (*Lates calcarifer*), mullet (*Mugil cephalus*), tarpon (*Megalops cyprinoides*) and snub-nose gar (*Arrhamphus sclerolepis*).

Table 7.2: Species list

Family	Species	Common Name
Anguillidae	*Anguilla reinhardtii*	Long-finned Eel , freshwater eel
Clupeidae	*Nematolosa erebi*	Bony bream
Osteoglossidae	*Scleropages leichardti*	Saratoga, spotted barramundi, Dawson River salmon
Ariidae	*Arius graeffei*	Fork-tailed catfish, lesser salmon catfish, blue catfish
Plotosidae	*Neosilurus hyrtlii*	Hyrtl's tandan, Hyrtl's catfish, butter jew
	Tandanus tandanus	Jewfish, freshwater catfish, Eel-tailed catfish
Atherinidae	*Craterocephalus stercusmuscarum*	Fly-speckled hardyhead
Melanotaeniidae	*Melanotaenia splendida splendida*	Eastern rainbowfish
Ambassidae	*Ambassis agassizii*	Agassizii perchlet, olive perchlet, glassfish
Percichthyidae	*Macquaria ambigua*	Yellowbelly, golden perch
Terapontidae	*Amniataba percoides*	Banded grunter, barred grunter, black striped banded trumpeter
	Leiopotherapon unicolor	Spangled perch
	Scortum hillii	Black bream, leathery grunter
Eleotridinae	*Hypseleotris sp. A*	Midgley's carp gudgeon
	Hypseleotris sp. B	Western carp gudgeon
	Oxyeleotris lineolatus	Sleepy cod
	Philypnodon grandiceps	Big-headed gudgeon, flathead gudgeon, longheaded gudgeon
Cyprinidae	*Carassius auratus*	Goldfish
Poeciliidae	*Gambusia affinis*	Mosquito fish

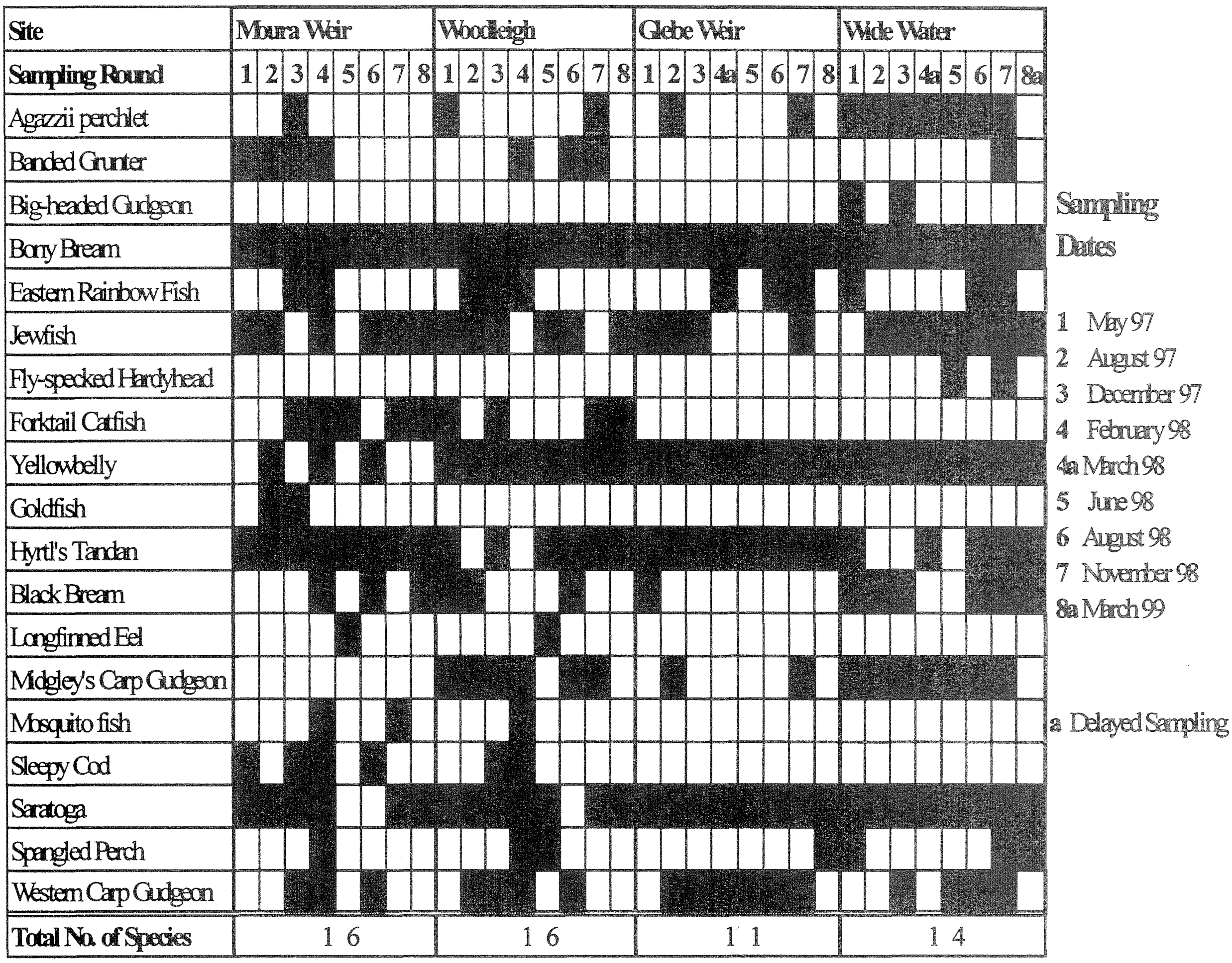
Fish Diversity

The study revealed that there were large variations in the numbers and species of fish captured between seasons and sites. Some trends noted were general spring/summer peaks in abundance but these were at times absent. A general fall in numbers in autumn was partially attributed to the lower number of bony bream captured. Figure 7.1 presents details of each species captured by date and site. One aspect to note is the decline in species from the mid to the upper section of the sub-basin.

Trap Captures

The trap captures at each site were commonly dominated by a single species, with the species varying depending on site and season. Across all sites Midgley's and western carp gudgeons and rainbow fish were the most abundant catch in traps. Glebe Weir provided the poorest return of total trap captures with 10 or less individuals encountered on 7 occasions, followed by Moura Weir with 20 fish or less captured on 7 occasions balanced with a return of 442 (dominated by rainbow fish) in the summer

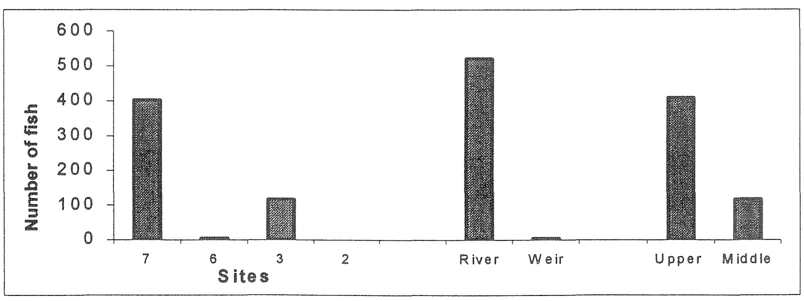
Figure 7.1: Fish species by location and date



of 1997/98.

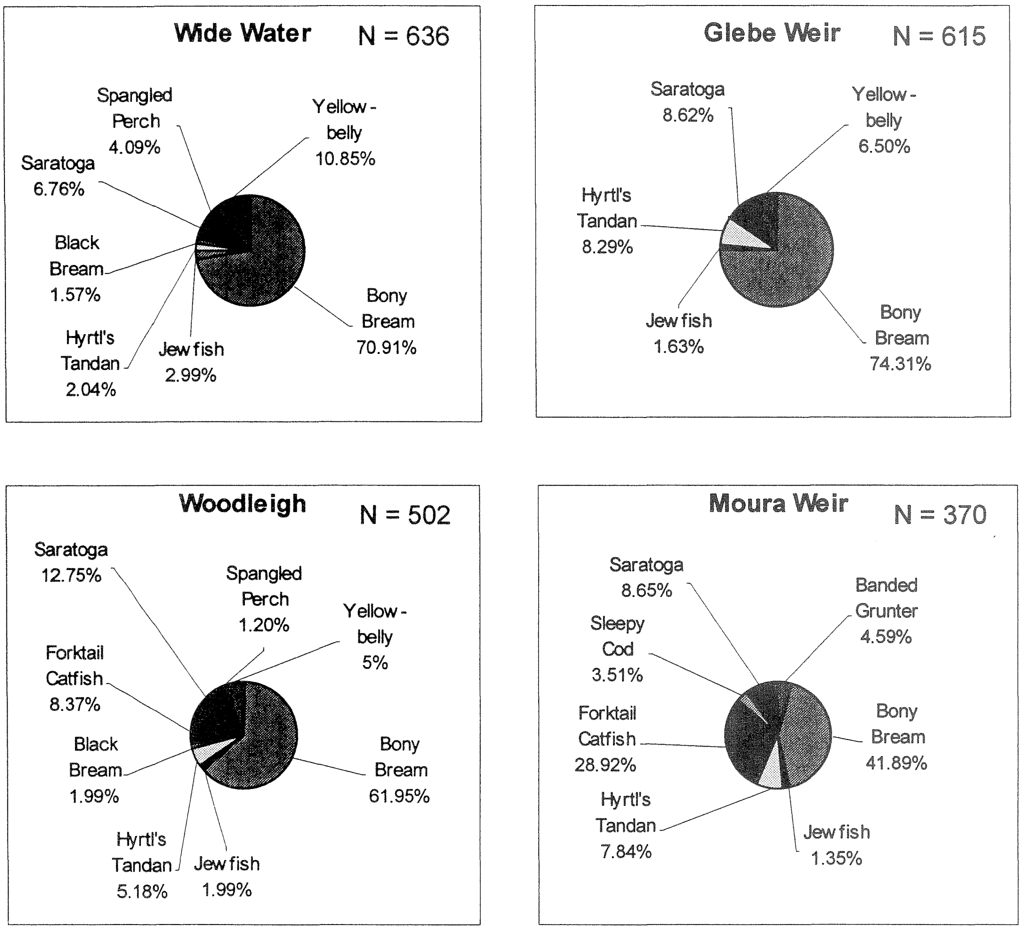
Midgley's carp gudgeon dominated Woodleigh trap catches except for the summer 1997/98 when rainbow fish were present in high numbers. Interestingly this was not repeated in the summer 1998/99. Trap captures at Widewater were the highest with a lone species, Agassizii perchlet captured on each occasion. The summer of 1998/99 saw a significant increase in numbers of Midgley's carp gudgeons captured but no new species were returned (Fig. 7.1).

Figure 7.2: Midgley's carp gudgeon



A comparison of the combined total for the upper- and mid-section sites found that there was approximately the same number of individuals captured from both the paired sites. Agassizii perchlet were highly abundant in the upper catchment with rainbowfish being similarly abundant in the mid catchment sites. There was a return of approximately four times the number of Midgley's carp gudgeons in the upper catchment when compared to the mid catchment sites (Figure 7.1). When compared to the mid Dawson sites, twice the numbers of western carp gudgeons were returned from the upper sites.

Figure 7.3: Total project net captures, species >1% reported only

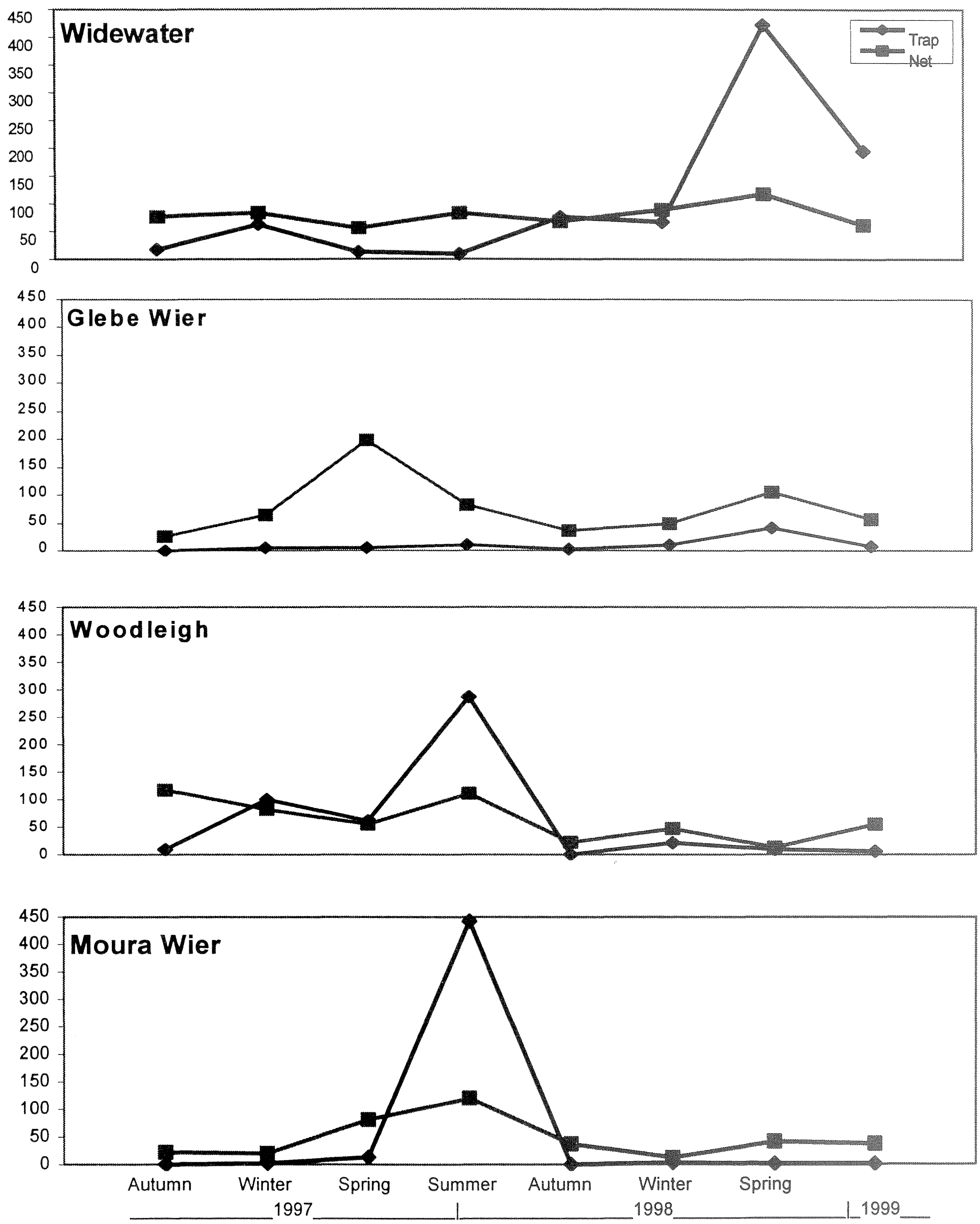


Further results identified the weirs returning half the total number of trap captures returned from the riverine sites. The numbers of rainbowfish, western carp gudgeons and fork-tailed catfish were relatively similar in the weir and riverine sites, whereas the riverine sites returned many more Agassizii perchlet and Midgley's carp gudgeons.

Net Captures

Catches in the gill and fyke nets also varied seasonally and were dependent on site and a general drop in numbers occurred during the autumn samplings. This could be attributed in part to the low numbers of bony bream moving and feeding in the colder months of the year (Merrick & Schmida, 1984). Widewater returned the most

Figure 7.4: Net and trap captures



consistent catches across the sampling period. The only peak noted was in the spring of 1998 due to an increase in bony bream abundance and relatively high numbers of saratoga present.

The recreationally important yellowbelly was captured at all sites and on each sampling except for Moura Weir (Fig. 7.1). Numbers were highest at Widewater where it made up 11% of the total net captures (Figure 7.3).
Glebe Weir had large variations in catches, with an increase in numbers of fish returned in the spring of both years (Fig. 7.4). This was influenced by an increase in the numbers of bony bream present. Woodleigh had peaks of catches in autumn 1997 and summer 1997/98 (Fig. 7.4). This was influenced by an increase in numbers of bony bream and saratoga captured. Woodleigh returned the greatest numbers of saratoga throughout the project.

Moura Weir was generally low in netted fish abundance except for a peak in summer 1997/98 where there was an increase in the numbers of bony bream and fork-tailed catfish (Fig. 7.3). No fork-tailed catfish were captured in upper catchment sites. This is consistent with all other fisheries sampling in the Dawson River (Berghuis & Long 1999; Long & Berghuis 1995). Moura Weir returned greater numbers of fork-tailed catfish than Woodleigh with peaks present in spring and summer 1998.

Exotic Species

Two species of exotic fish were captured in the project, the common goldfish (*Carassius auratus)* and the mosquito fish (*Gambusia holbrooki*). Goldfish were returned on two occasions at Moura Weir. Mosquito fish were captured at Woodleigh on one occasion and Moura Weir on two occasions.

DISCUSSION

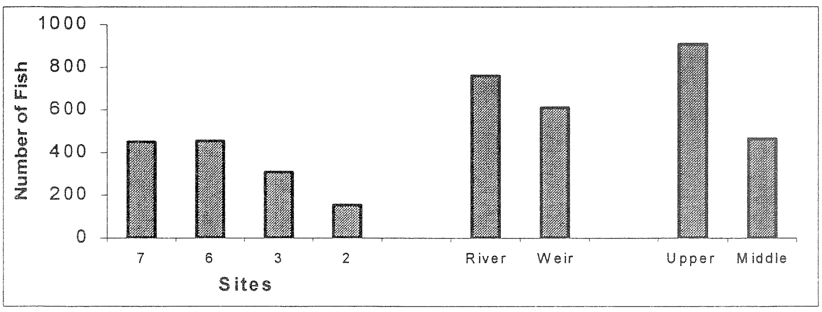
Three of the four sites saw peaks of captures in either the spring or summer samplings. This reflects the ability of fish to reproduce and recruit in numbers to take advantage of rapid growth across summer (Merrick & Schmida 1984). It is also a reflection that the most dominant species captured, bony bream, is more likely to be captured in the warmer months. This may be more a record of its need to feed more at higher temperatures and hence move with the result that it is captured in the sampling apparatus.

Principle Species

Bony Bream

Bony bream dominated individual species captured in nets at all sites with a mean of 67% and a range of 45% (Moura Weir) to 82% (Glebe Weir) of the total catch.

Figure 7.5: Bony bream captures

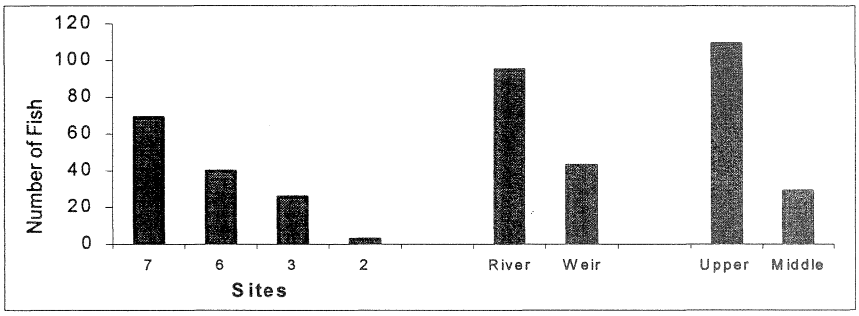


The number of bony bream captured in the upper catchment sampling sites was approximately twice the number captured at the mid section sites (Figure 7.5). There was no significant difference in the number of individuals captured in weirs compared to the riverine sites (Figure 7.5). The number of bony bream declined during autumn each year and this trend was reflected at all sites except for the first sampling at Woodleigh. In a previous study (Berghuis & Long 1999) bony bream dominated gill net captures throughout the Fitzroy Catchment with an overall return of 75% of fish captured in nets. Within the Murray–Darling Basin, Puckridge & Walker (1990) have documented this highly fecund herbivore as increasing in numbers against trends of instream habitat loss and regulated flows, whilst other native species decline in numbers.

Yellowbelly

Yellowbelly (golden perch) is the most targeted freshwater recreational species in the Dawson sub-basin (Long & Berghuis 1995) and was found at all sites. The highest capture rate was at the upper riverine site, Widewater. Conversely, Moura Weir had a very low percentage of golden perch captures (0.45%). Substantially more yellowbelly were returned during the winter samplings at all sites. This is in line with the returns of recreational anglers who capture more yellowbelly in the winter months in the Dawson sub-basin (Long & Berghuis 1995).

Figure 7.6: Yellobelly captures



When comparing the results of the upper and mid section sites it was found that the number of yellowbelly captured in the upper sites was approximately three times the number captured in the mid section sites (Fig. 7.6). A comparison of the captures from weirs and riverine sites found that approximately twice the number of individuals were captured in the riverine sites (Fig. 7.6). It is suggested that the six weirs would have had a negative impact upon yellowbelly numbers as it is a migratory spawner, requiring summer floods to successfully recruit (McDowall 1996). There is 245 km of river from the lowest weir (Neville Hewitt) to the uppermost weir (Glebe) above which the Dawson is uninterrupted for approximately 140 km. The lack of barriers in the upper sub-basin would allow this species to complete its spawning and recruitment which may account for the higher numbers of yellowbelly captured at Widewater.

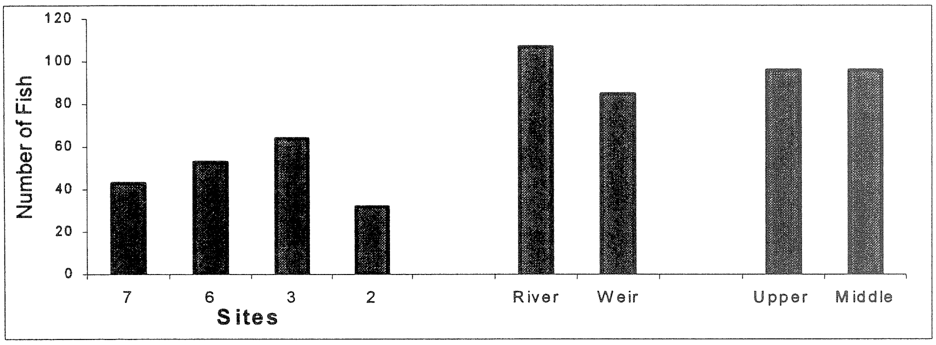
In the past 13 years in excess of 260,000 yellowbelly have been stocked into the Dawson River under the DPI's Freshwater Recreational Fishing Enhancement Program. The basis of the stocking is to enhance the yellowbelly fishery of the

Dawson. It is unclear at this time as to what impact the introduction of hatchery reared fish has had. To date we do not have a means of identifying whether a fish is "wild" or hatchery produced.

Saratoga

Saratoga are the second most targeted freshwater recreational species recorded at the four sites. Saratoga were captured at all sites with individuals ranging from 235 mm up to 730 mm. In the riverine sites, 43 saratoga were found at Widewater and 64 at Woodleigh. The weirs produced 53 individuals at Glebe Weir and 32 at Moura Weir (Figure 7.7).

Figure 7.7: Saratoga captures



Saratoga were captured in greater numbers in the warmer months and again this is reflective of angler returns (Long & Berghuis 1995). This species is endemic to the Fitzroy Catchment but in recent years has been translocated to many southern Queensland coastal impoundments.

Fork-tailed catfish

Fork-tailed catfish were only captured at the two mid catchment sites (Figure 7.1). They particularly dominated catches at Moura Weir (29%) while making up only 8% of the catch at Woodleigh (Figure 7.3). This species is a strong migrator yet has never been reported above Glebe Weir even though it would have the opportunity in larger flood events (Long, P. 1999 pers comm). This phenomena has been noted in other sub-basins of the Fitzroy Catchment where fork-tailed catfish are only recorded up to a certain point in the sub-basin (Berghuis & Long 1999). A possible thermal barrier to their upstream migration has been ruled out as they inhabit catchments in regions more temperate than the Fitzroy (Merrick & Schmida 1984).

Other Species

A comparison of the captures from the upper- and mid-section sites found that the relative abundance of Hyrtl's tandans were approximately the same. There was double the number of hyrtl's tandans captured in weirs. It was found that there was a similar number of black bream captured in the upper and mid section sites. The number of black bream captured in the river was five times that of the weirs.

Similar to the fork-tailed catfish result, no banded grunter or sleepy cod were recorded in the upper sites, while both were regularly returned in the mid section sites. The number of spangled perch captured in the upper sites was three times the number captured in the mid section sites. The riverine captures were eight times higher than the number captured in weirs.

Jewfish (*Tandanus tandanus*) have a complicated spawning ritual and are one of the few freshwater fish species that use a nest to incubate their eggs (Merrick & Schmida 1984). The nest is often constructed of sand and gravel. The need for this substrate influences the areas that this species inhabits. The weir environment is generally not suited to the jewfish as they are bottom feeders and oxygen levels at the bottom of the weirs are often below fish supporting levels. They show very limited movement, with most individuals moving less than five kilometres in a lifetime (Merrick & Schmida 1984) and are not likely to migrate into a weir environment. This is supported by the compilation of the riverine and weir results with the capture of jewfish in the riverine sites twice the number of weir captures. The number of jewfish captured in the upper sites was double the number caught in the mid section sites.

Exotic Species

Two species of exotic fish were captured at Woodleigh and Moura. To expand to this range Berghuis & Long (1999) reported capturing goldfish in an upper catchment site. The goldfish present would have more than likely been released from domestic aquaria, whilst the mosquito fish were released by some local authorities several decades ago in a failed attempt at controlling mosquito populations (Merrick & Schmida 1984). It has now been established that populations of rainbow fish and pacific blue-eye's have, under most circumstances, a more significant impact upon mosquito populations.

Goldfish have been reported in the Fitzroy Catchment for over 30 years (Long & Berghuis 1995), but they do not appear to have established a significant population or displaced native fish populations. However there is evidence of large localised populations of mosquito fish which are known to aggressively out compete native fish communities (Allen 1989).

It is unfortunate that these two species occur in the catchment, but this compares favourably with reports of ten exotics in the Murray-Darling Basin (Morrison 1988). European carp (*Cyprinus carpio)* that has had the greatest impact in the Murray-Darling basin has so far not been recorded in the Fitzroy Catchment. If this species was established in the Fitzroy Catchment, similar negative impacts on the ecology of the river and disruptions to recreational angling could be expected.

Fish Migration

Of the 19 species that were captured in the study, 79% are known to be migratory with 40% needing to migrate to reproduce (Cotterell & Jackson 1998). There are two principle reasons for fish migration; reproduction and dispersal. Certain species need to migrate to reproduce and therefore have obligatory migration, either in freshwater, to the sea or from the sea to freshwater. Dispersal or opportunistic migration occurs where fish take advantage of flows within rivers to move from one point to another, with the goal to populate as much available habitat as possible that such ensures survival of the species.

The Dawson sub-basin has six weirs which act as stream barriers to fish migration, either temporarily or permanently. It is known that fish will migrate upstream in flood flows (Mallen-Cooper 1994; Stuart & Mallen-Cooper 1999) and if weirs are drowned out then they will travel over them. Not all fish passage is possible however in the limited drown out period, or the barrier may not drown out at all (eg. higher weirs and dams). This is where provision for fish passage in the form of fish ladders is required. Stream barriers can lead to extinctions of fish in a catchment or localised extinction as has been demonstrated for barramundi, mullet, tarpon and snub-nose gar in the Dawson sub-basin. Within the Dawson sub-basin therefore there is concern about the future of the yellowbelly and black bream because of their reliance upon flood flows to migrate, successfully reproduce and recruit in sufficient numbers to maintain a self-sustaining population.

CONCLUSIONS

This fisheries study clearly identified the differences in the fish communities of weir and riverine sites in the Dawson sub-basin. There are seasonal trends in individual species with the data suggesting a need for concern over the future fate of several species. The direct and indirect impacts of catchment modification, current land use practices, stream barriers and stream water quality on fisheries need further investigation to establish long term trends in the complex fish community. In light of the proposals to further modify the catchment with the construction of an additional weir and a large storage, and the subsequent impact on stream flows, it is important to undertake further studies to assess these impacts. In the future all new water infrastructure projects will need to be better managed to mitigate any potential adverse impacts to native fish populations.

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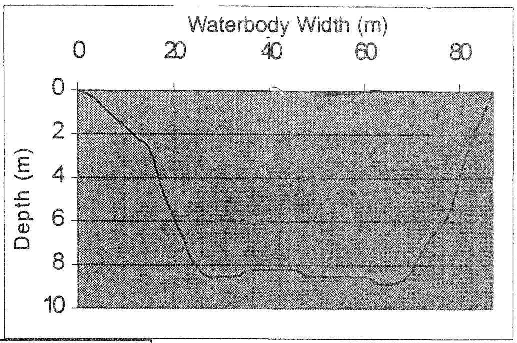
Site Two - Moura Weir

Latitude[1]	Longitude[1]	AMTD[2] (Km)
149°55"12' E	24°36"16' S	150

[1] As recorded by Garmin GPS 45
[2] Adopted Middle Thread Distance, Kilometers upstream of the confluence with the Mackenzies River

Habitat description of Site One

Waterbody Type	Impoundment	
Flow Type	Pool	
Land Tenure	Freehold/Leashold	
Stream Structure*		
Total Length	32km	
Max. Depth	10m	
Max.Width	87m	
Average Width	80m	
Sediment	Fine Material	
Aquatic Macrophytes		
% Wetted Area	0	
No. of species	0	
Riparian Vegetation	**Left Bank**	**Right Bank**
Width	30	20
Continuity	90	100
% Trees/Shrubs	50	50
% Grasses	70	30
% Other	0	0
% No Vegetation	0	30
Adjacent Land Use	Grazing	Cultivation



* at sampling site

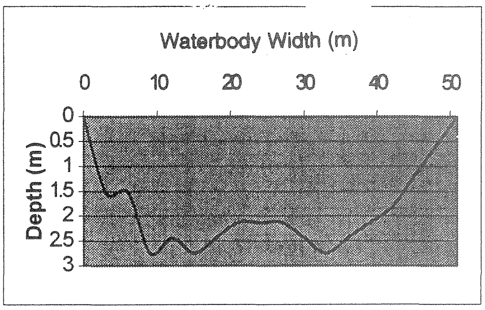
Site Three - Woodleigh

Latitude[1]	Longitude[1]	AMTD[2] (Km)
149°58"12' E	24°48"01' S	173

[1] As recorded by Garmin GPS 45
[2] Adopted Middle Thread Distance, Kilometers upstream of the confluence with the Mackenzies River

Habitat description of Site Two

Waterbody Type	River	
Flow Type	Pool	
Land Tenure	Freehold/Leashold	
Stream Structure*		
Total Length (km)	1km	
Max. Depth (m)	4	
Max.Width (m)	51	
Average Width (m)	40	
Sediment	Fine Material	
Aquatic Macrophytes		
% Wetted Area	0	
No. of species	0	
Riparian Vegetation	**Left Bank**	**Right Bank**
Width (m)	15	30
Continuity	80	90
% Trees/Shrubs	80	80
% Grasses	70	0
% Other	0	0
% No Vegetation	0	0
Adjacent Land Use	Grazing	Cultivation



* at sampling site

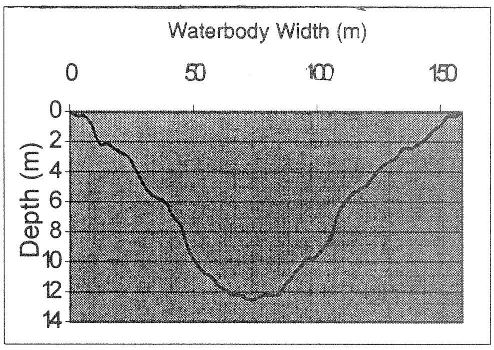
Site Six – Glebe Weir

Latitude[1]	Longitude[1]	AMTD[2] (Km)
150°00"00' E	25°29"05' S	326

[1] As recorded by Garmin GPS 45
[2] Adopted Middle Thread Distance, Kilometers upstream of the confluence with the Mackenzies River

Habitat description of Site Six

Waterbody Type	River	
Flow Type	Pool	
Land Tenure	Freehold/Leashold	
Stream Structure*		
Total Length (km)	30km	
Max. Depth (m)	13m	
Max.Width (m)	160m	
Average Width (m)	150m	
Sediment	Fine Material	
Aquatic Macrophytes		
% Wetted Area	0	
No. of species	0	
Riparian Vegetation	**Left Bank**	**Right Bank**
Width (m)	30	50
Continuity	100	100
% Trees/Shrubs	40	20
% Grasses	30	30
% Other	0	0
% No Vegetation	30	30
Adjacent Land Use	Grazing	Grazing



* at sampling site

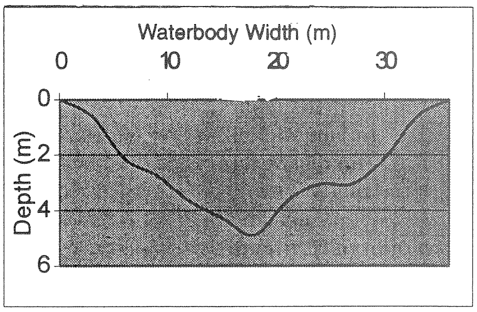
Site Seven – Widewater

Latitude[1]	Longitude[1]	AMTD[2] (Km)
149°47"47' E	25°36"43' S	379

[1] As recorded by Garmin GPS 45
[2] Adopted Middle Thread Distance, Kilometers upstream of the confluence with the Mackenzies River

Habitat description of Site Seven

Waterbody Type	River	
Flow Type	Pool	
Land Tenure	Freehold/Leashold	
Stream Structure*		
Total Length (km)	3km	
Max. Depth (m)	6m	
Max.Width (m)	46m	
Average Width (m)	36m	
Sediment	Fine Material	
Aquatic Macrophytes		
% Wetted Area	0	
No. of species	0	
Riparian Vegetation	**Left Bank**	**Right Bank**
Width (m)	8	10
Continuity	90	80
% Trees/Shrubs	90	90
% Grasses	10	40
% Other	10	75
% No Vegetation	0	0
Adjacent Land Use	Grazing	Recreation



* at sampling site

Appendix A

PROJECT TEAM

Principal Investigators

Bob Noble	Project Leader, DNR Rockhampton
Dr Leo Duivenvoorden	Coordinator, Biological studies (excluding Fisheries), Central Queensland University (CQU)
Peter Long	Coordinator, Fisheries studies, DPI Rockhampton
Catherine Collins	Project Officer, DNR Biloela Research Station
Dr Larelle Fabbro	Algal studies, Central Queensland University (CQU)

Activities

- Water and Algal Sampling – Physico-Chemical Parameters
  Bob Noble, Catherine Collins and Bruce Cowie

- Rainfall and Streamflow Data
  Ian Wallace

- Map Preparation
  Mervyn Leslie

- Fisheries Studies and Invertebrate and Zooplankton Sampling
  Peter Long, Craig Broadfoot, DPI Rockhampton

- Algal and Invertebrate Analysis
  Dr Leo Duivenvoorden, Dr Larelle Fabbro, CQU Rockhampton

- Aquatic Vegetation
  Dr Leo Duivenvoorden, CQU Rockhampton

Unless otherwise indicated, project team members are from the Department of Natural Resources (DNR), Central West Region

Appendix B

SITE DESCRIPTIONS

Map 1 shows the location of the Primary and Secondary River Sites that were sampled in this project. Descriptions of each site with accompanying photographs are presented below.

Site 1 – Baralaba, Neville Hewitt Weir

149°48' S 24°10' E

Impounded water behind the weir on the outskirts of the town of Baralaba. The site is behind the weir wall with water samples collected during river flows. Urban and recreational activities and grazing, with dryland (wheat, sorghum, forage) and irrigated (cotton) cropping are located nearby.

Site 2 – Moura Weir

24° 36' S 149° 55' E

This mid sub-basin site is located near the road bridge in the impounded water behind Moura Weir. The weir impounds water for 32 km and has a maximum depth of 10 m. The maximum width of the pool is 87 m and the average width is 80 m. The riparian zone is lightly wooded and grassed. The site is well used recreationally. Surrounding land uses include urban, irrigated and dryland cropping, grazing and extensive coal mining.

Site 3 – Woodleigh

24° 48' S 149° 58' E

This mid sub-basin riverine site is located up stream from the Moura Weir. The pool has a total length of 1 km and a maximum depth of 4 m. The maximum width of the pool is 51 m with the average width being 40m. The riparian zone is a mixture of trees, shrubs and grasses. This site is a well-known recreational fishing hole. Surrounding land use includes grazing and cultivation.

Site 4 - Theodore Weir

150° 74'S 24° 69' E

The site is impounded water near the town of Theodore, directly behind the weir wall. Samples were taken as the water flowed over the weir. The riparian vegetation is lightly wooded and well grassed. Land and water uses are mainly urban and irrigated cropping (cotton), with grazing and dryland cropping.

Site 5 – Orange Creek Weir

25° 13' S 150° 12' E

Impounded water downstream from Gyranda Weir but upstream from Theodore on the Dawson River. Orange Creek weir is popular for fishing and camping activities.

The site was chosen due to its similarity in size and depth to Moura Weir for comparing blue green algae populations. The weir is not influenced by irrigation cropping activities and was used to determine the effect of nutrients and chemicals on the water quality. The riparian vegetation is well established along the banks dominated by the Dawson Palm in sections. Grazing and forage cropping activities are adjacent to the weir. Flow into the weir is dominated by releases from Gyranda weir.

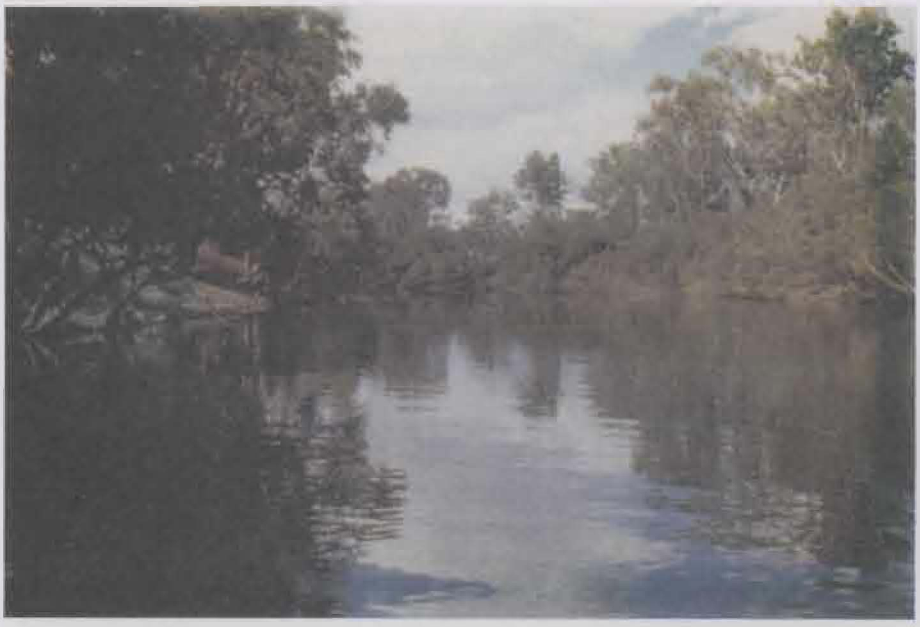
Site 6 – Glebe Weir

25° 29' S 150° 00' E

This upper sub-basin impoundment site is located in the impounded water behind Glebe Weir. The weir impounds water for 30 km with a maximum depth of 13 m. The maximum width of the site is 160 m with the average width being 150 m. The riparian zone consists of trees and shrubs with grass in some places. Adjacent land use is dominated by grazing.

Site 7 – Widewater

25° 36' S 149° 47' E



This riverine site is located in the upper Dawson sub-basin near Taroom. The pool has a total length of 3 km and a maximum depth of 6 m. The sampling site had a maximum width of 46 m and an average width of 36 m. This site is recreationally important. The riparian zone consists primarily of trees and shrubs with limited grasses growing. Surrounding land use includes recreation and grazing.

Site 8 – Taroom

25° 38' S 149° 47' E

Situated at the old highway bridge just outside of the township of Taroom, the Dawson River in flood. Samples were collected during times of river flow. The banks are well grassed and support established riparian vegetation. Land uses nearby include urban, recreational, grazing and dryland cropping activities.

Site 9 – Juandah Creek

26° 01' S 149° 53' E

A sampling site situated off the road bridge on Juandah Creek. The creek drains water from Bungaban Creek, Horse Creek, Wandoan Creek and Roche Creek, the water from the Wandoan region. Juandah Creek meets the Dawson River just south of Taroom on the Roma Road. The site is a rock-lined pool that filters through open woodland vegetation and along open grassland country to enter the Dawson River. Neighbouring land uses include grazing and dryland cropping activities.

Site 10 – Tarana Crossing

149° 33' E 25° 47' S

A road crossing downstream from the Eurombah Creek junction with the Dawson River. The site is upstream from Taroom . A narrow site that has steep sides, and regular flowing water. Adjacent land uses include mainly grazing with a small area of irrigated cotton.

Site 11 – Baroondah

25° 69' S 149° 019' E

Just upstream of the Yebna Crossing on the upper Dawson- an upper catchment site with shallow (1m) but permanent low flow over a sandy substrate. The riparian zone is well grassed and wooded in a narrow strip. Land use is dominated by grazing and forestry reserves with small areas of cropping near Injune.

Appendix C: Community Activities

Table 1: School visits by the Catchment Trailer 1997-1999

School Name	Student Numbers	Education District
Taroom SS	]	Chinchilla
Peak-A-Doo SS	]	Chinchilla
Grosmont SS	] 256	Chinchilla
Wandoan SS	]	Chinchilla
Cockatoo SS	]	Chinchilla
Ambrose SS	43	Gladstone
Jambin SS	46	Gladstone
Mount Murchison SS	60	Gladstone
Home Schooling Group	25	Gladstone
Moura SS	37	Gladstone
Moura SHS	40	Gladstone
Theodore SS	20	Gladstone
Thangool SS	22	Gladstone
Wowan SS	27	Gladstone
Marlborough SS	38	Rockhampton
Byfield SS	*	Rockhampton
Milman SS	*	Rockhampton
The Caves SS	*	Rockhampton
Ridgelands SS	]	Rockhampton
Dalma SS	] 100	Rockhampton
Stanwell SS	]	Rockhampton
Bajool SS	32	Rockhampton
Bouldercombe SS	8	Rockhampton
Clarke Creek SS	22	Rockhampton
Duaringa SS	25	Rockhampton
Gogango SS	9	Rockhampton
Westwood SS	21	Rockhampton
Mt Morgan SHS	*	Rockhampton
Gracemere SS	28	Rockhampton
Glenmore SS	66	Rockhampton
Mount Archer SS	69	Rockhampton
Parkhurst SS	46	Rockhampton

Mt Chalmers SS	29	Rockhampton
Coowonga SS	23	Rockhampton
Nerimbera SS	44	Rockhampton
Farnborough SS	15	Rockhampton
North Rockhampton SS	*	Rockhampton
Bersecker Street SS	*	Rockhampton
Frenchville SS	*	Rockhampton
Cawarral SS	23	Rockhampton
Emmaus College – Yr 10	18	Rockhampton
Rockhampton SHS	35	Rockhampton
Woorabinda SS	46	Rockhampton
Depot Hill SS	*	Rockhampton
Ogmore SS	8	Mackay Hinterland
West Hill SS	13	Mackay Hinterland
St Lawrence SS	17	Mackay Hinterland
Carmila SS	47	Mackay Hinterland
Gindie SS	38	Emerald
Bluff SS	46	Emerald
Comet SS	40	Emerald
Emerald SHS	109	Emerald
Emerald North SS	81	Emerald
Emerald SS	36	Emerald
St Patricks Primary	46	Emerald
Tieri SS	60	Emerald
Springsure SS	44	Emerald

Table 2: Events attended by the Catchment Trailer 1997-1999

Show/Event	Group	Year			Duration
		97	98	99	
Beef 97	Meat & Livestock Corp, TBC-DPI	√			3 days
Wandoan Show	Taroom Shire Landcare Group	√			2 days
Taroom Show	Taroom Shire Landcare Group	√			2 days
Theodore Show	Theodore Landcare	√	√		2 days
Biloela Show	Callide Valley Landcare	√	√	√	2 days
Clermont Show	Mistake Creek Landcare Group	√			2 days
Emerald Show	DPI	√			2 days
Springsure Show	Local Council		√		1 day
Baralaba Show	Baralaba Landcare		√	√	2 days
Ridgelands Show	Ridgelands/Momish Landcare			√	1 day
Ecofest 99 – Boyne Island	Boyne Island Education Centre			√	1 day
Options 97-Thangool	Callide Valley Landcare Group	√			2 days
Fieldfest – Rockhampton	DNR/Capricorn Coast Landcare	√			3 days
Agrow 2000 – Emerald	Agforce – Central Highlands			√	3 days
Looking Forward Conference - DCCA	NHT Project Display/DCCA	√			2 days
SILO Markets – Biloela	Callide Valley Landcare Group	√√	√√	√	1 day, 3 times a year
Regional Landcare Conference	NHT Project display	√	√		2 days
Australia Day Awards – Emerald	Bogantungan Landcare Group		√	√	1 day
Landcare & Catchment Forum				√	1 day
Morinish/Ridgelands Field Day	Morinish/Ridgelands Landcare Group			√	1 day
Sustainable Futures Symposium - FBA	FBA - Rockhampton	√			2 days
Emerald Environmental Convention	Central Highlands Groups (Landcare, FBA, etc)		√	√	2 days
Primary Industries Week	DNR/DPI		√		1 day