Research priorities for conservation and management of freshwater resources in the Australian Wet Tropics:

Water Research Plan

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Rainforest CRC

Cooperative Research Centre for
Tropical Rainforest Ecology
and Management

Published by the Cooperative Research Centre for Tropical Rainforest Ecology and Management. Further copies may be requested from the Rainforest CRC, PO Box 6811, Cairns, QLD 4870, Australia.

This report, *Research priorities for conservation and management of freshwater resources in the Australian Wet Tropics: Water Research Plan* includes outcomes of the CRC's Water Research and Development Workshop held in Cairns in October 2000.

December 2001

Other works published by The Cooperative Research Centre for Tropical Rainforest Ecology and Management:

Patch Deaths in Tropical Queensland Rainforests: association and impact of *Phytophthora cinnamomi* and other soil borne organisms. *Editor: Paul Gadek.*

Remote Sensing Requirements for Management Agencies Responsible for Forest and Water Quality Monitoring in the Wet Tropics. *Stuart Phinn, Michael Stanford, Alex Held.*

The Comparative Assessment of Arthropod and Tree Biodiversity in Old-World Rainforests: The Rainforest CRC / Earthwatch Protocol Manual. *Roger Kitching, Guy Vickerman, Melinda Laidlaw, Karen Hurley.*

Impacts of Roads and Powerlines on the Wet Tropics World Heritage Area. *Miriam Goosem, Steve Turton.*

Impacts of Visitation and Use: Psychosocial and Biophysical Windows on Visitation and Use in the Wet Tropics World Heritage Area. *Joan Bentrupperbäumer, Joseph Reser.*

Feral Pigs: Pest Status and Prospects for Control. *Editor: Chris Johnson.*

Evaluating the feasibility of remote sensing for monitoring State of the Wet Tropics Environmental Indicators. *Stuart Phinn, Michael Stanford, Alex Held, Cathertine Ticehurst.*

CONTENTS

EXECUTIVE SUMMARY

What are the needs for Research and Development in water-related issues in tropical rainforests? This is a question relevant to the Rainforest CRC, whose mission is to support the sustainable use, management and conservation of Australia's tropical rainforests. In addressing this question, researchers from CRC Project 1.3 *Project Designs for Essential Infrastructure* conducted a water Research and Development (R and D) workshop in Cairns on 24 October 2000, and developed the *Research priorities for conservation and management of freshwater resources in the Australian Wet Tropics: Water Research Plan.*

This report describes the workshop, includes speaker abstracts and summaries of workshop discussions, and presents the *Water Research Plan.* The concept of the *Water Research Plan* involves a range of activities that will deliver outputs and outcomes in the short, medium and long-term, building initially upon individual areas of researcher expertise, and integrating them within a broad theme relating to the ecology and management of water resources and infrastructure.

The *R and D Plan* takes into account key planning documents, including *The Wet Tropics Information Needs for Management* (WTMA 2000) and the *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999).

The *Research Priorities for conservation and management of freshwater resources in the Australian Wet Tropics: Water Research Plan* is summarised in Figure 1. As shown in the Plan, the major outputs of the research program are guidelines and training materials for best practice water management in the Wet Tropics, covering three major areas:

- Infrastructure Design in Rainforest Catchments
- Provision of Environmental Flows in Rainforest Streams
- Maintenance and Restoration of Rainforest Stream Ecosystems

Elements of the water *Water Research Plan* have been funded for 2001/2002 and are now incorporated into CRC Research Program 4 – *Rainforest Access: Managing and Monitoring Impacts*, under the new research project title *Project 4.4 - Water Resources: Ecology and Management*. The relocation to Program 4 was undertaken to help ensure: (i) that there is complementarity rather than overlap between the two CRC programs that deal with infrastructure and impacts, and (ii) that the appropriate expertise is being applied to such projects. Major tasks in Program 4 water research are outlined on the CRC's Web site <www.rainforest-crc.jcu.edu.au>.

RESEARCH DIRECTIONS *2001-2002*

Project 4.4 will focus substantial effort on production of outputs from previous research during 2001/2002 (Table 1). Some CRC funding will be used to maintain or establish vital new research and to ensure that ongoing CRC funded and new externally funded research will not lose momentum.

Table 1 Research outputs expected in 2001/2002

Output	Output type	*Project Team	Timetable for Submission
Report on Water Workshop – R and D Needs for Water in the Wet Tropics	CRC tech report	RK, AA (Eds)	Dec 2001
Annotated Bibliography of Planning and Management Guidelines	CRC tech report	RK, JP, AA, RP, BP	June 2002
Annotated bibliography of stream process and condition data for north-east Queensland	CRC tech report	RK, AA, RP, BP	June 2002
Stream rehabilitation training workshop for practitioners and managers	Training workshop	RK, RP	June 2002
CRC Monograph on Biology and Environmental Flow Requirements of Queensland Freshwater Fishes	CRC Monograph	BP, AA, Kennard	June 2002
Guide to monitoring stream health using macroinvertebrates	CRC tech report	RP	March 2002
Rapid biophysical assessment of stream condition	CRC tech report	RP, AA, BP, Werren	June 2002
Report on workshops – Recreation and Water Quality	CRC tech report	RP, Butler	March 2002
Report on aquatic plants of the Mulgrave River	CRC tech report to WTMA	GW, BP, AA, Cairns	June 2002
Determinants of freshwater fish biodiversity in rivers of north-eastern Australia	Journal article, *Hydrobiologia*	BP, AA, Kennard	Feb 2002
Distribution of freshwater fish in north-eastern Australia: landscape filters in multiple catchments	Journal article, *Ecology of Fresh -water Fish*	BP, AA, Kennard	June 2002
Assessing the biodiversity of freshwater fishes: considerations at various spatial and temporal scales	Journal article, *Marine and Fresh -water Research*	Kennard, BP, AA	June 2002
Utility of the RIVPACS modeling methodology for prediction of freshwater fish assemblages and detection of anthropogenic disturbance	Journal article *Freshwater Biology*	Kennard, AA, BP	Dec 2001
Spatial variation in the distribution and abundance of submersed aquatic macrophytes in an Australian subtropical river	Journal article *Aquatic Botany*	Mackay, AA Kennard, BP	Dec 2001
Report on Benchmarking Methodology for Environmental Flow Assessments	DNRM and Griffith Uni Tech Report	Brizga, AA, BP, Kennard, Mackay, Werren	June 2002
Responses of invertebrate communities to low dissolved oxygen concentrations in Wet Tropics streams	Journal *Freshwater Biology*	RP, Connolly, Crossland, Butler	March 2002
Responses of selected fishes to low dissolved oxygen concentrations in Wet Tropics streams	Journal article *Freshwater Biology*	RP, Connolly, Crossland, Butler	March 2002
Responses of invertebrate communities to high suspended sediment loads in Wet Tropics streams	Journal article *Marine and Fresh -water Research*	RP, Connolly, Crossland	June 2002
Impacts of deforestation on stream ecology In: Forests - Water - People in the Wet Tropics	Monograph article (Ed. Bonell)	RP, Connolly	Jan 2002

Effects of nitrate and phosphate enrichment on forest stream ecology	Journal article *Freshwater Biology*	RP, Connolly, Crossland	June 2002
Water quality of Wet Tropics streams	Journal article *Marine and Fresh -water Research*	RP, Butler	April 2002
Evolution and systematics of leptophlebiid mayflies	PhD thesis	Christidis (Pearson)	July 2002
Ecology of stream-dwelling chironomids	PhD thesis	McKie (Pearson)	Feb 2002

ON-GOING RESEARCH

The project team is committed to pursuing on-going and new research during 2001-2002 because to call a complete halt to new research at this stage would lead to irreparable damage to the overall CRC water research project. This project builds on earlier research, and introduces new tasks relevant to appropriate management of streams in the Wet Tropics. Tasks on the research agenda and their proposed status for the coming year are outlined in Table 2.

Table 2 Ongoing research tasks

Task	***Project Leaders**	**Project-funded Staff**	**Status 01 - 02 (assumes minimal funding)**
R & D Needs and Infrastructure Audit	JP, AA, RP	Kapitzke	To be completed
Stream rehabilitation protocols and techniques	JP, AA, RP	Kapitzke, Pusey, Connolly	On-going
Culvert fishway laboratory model and prototype	JP, RP	Kapitzke, Patterson, Pearson	On-going (supported by Main Roads Dept 01-02)
Road drainage, waterways and fauna crossings	JP, AA, RP	Kapitzke, Butler	Dependent on level of funding (e.g. Main Roads). Seeking external funding for post-grad student
Environmental quality and ecological sustainability	RP, JP	Connolly, Crossland, Butler, Kapitzke	On-going; partly funded by SRDC
River ecology and environmental flows	AA, RP	Pusey, Connolly, Werren	Fish work continuing (AA , BP); Invertebrate work subject to funding (RP, Connolly)
Best practice management: Mulgrave River case study	AA, JP, RP	Pusey, Kapitzke, Connolly, Werren	Seeking CRC start-up funding for 2001-2002. Workshop April 2002.
Recreation and water quality	RP, AB	Butler *et al.*	Phase 2 to be completed; new developments subject to funding
Emerging topics: • Water storage development and management • Interbasin transfers • Salt intrusion in wetlands • Wetlands ecology and management • Fate of organic material in agricultural drainages			On agenda for future research, funding to be sought as opportunities arise

*AA = Angela Arthington, BP = Brad Pusey, JP = John Patterson, RK = Ross Kapitzke, RP = Richard Pearson

INTRODUCTION

What are the needs for Research and Development (R and D) in water-related issues in tropical rainforests? This is a question relevant to the Rainforest CRC, whose mission is to support the sustainable use, management and conservation of Australia's tropical rainforests. In addressing this question, researchers from CRC Project 1.3 *Project Designs for Essential Infrastructure* (now Project 4.4 *Water Resources, Ecology and Management*) conducted an R and D workshop in Cairns on 24 October 2000, and have used the workshop outcomes to develop a Water Research Plan for the region. The Water Research Plan involves a range of activities that will deliver outcomes in the short, medium and long-term, building initially upon individual areas of researcher expertise, and integrating them within a broad theme relating to the ecology and management of water resources.

At this Workshop, key researchers and stakeholders were invited to give their perspectives and join in a discussion of the issues and opportunities for water R and D. The objectives of the workshop were to:

- identify capabilities and interests of CRC researchers with respect to water issues
- identify major water R and D issues for stakeholders
- identify gaps in present knowledge relating to water issues
- determine priorities for future research
- identify funding options
- compile workshop outcomes for wider publication within the CRC.

This Water Research Plan presents the key outcomes from the workshop and develops a research strategy to take account of other research topics and priorities for the region, including *The Wet Tropics Information Needs for Management* (WTMA 2000) and the *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999).

The report is structured as follows: Chapter 2 outlines the workshop program and provides a list of attending delegates. Researcher and stakeholder presentations and associated discussions are presented in Chapters 3 and 4. Chapter 5 summarises the Water Research Plan, which has been based on the workshop outcomes and the previously identified R and D needs for the region. The research projects comprising the Water Research Plan are presented in Appendices A – G.

In welcoming participants to the workshop in October 2000, Councillor Mike Berwick, Mayor of Douglas Shire made the following key points and concluded by emphasising the need for a regional perspective on water quantity and quality:

- there is insufficient water of high quality in the Wet Tropics World Heritage Area and the impacts of tourism are a major concern
- water supplies for future populations around Cairns City are a critical issue in the region
- many major challenges in water conservation and management lie outside the WTWHA
- nutrient and sediment inputs to streams and coastal waters are a major water quality issue
- sources of nutrients and sediments are roads, hillside development, urban and sewage wastewater, agricultural landuse and feral pig damage.

STRUCTURE OF WATER RESEARCH AND DEVELOPMENT WORKSHOP

The Water R and D Workshop was held over a full day in Cairns on 24 October 2000. CRC researchers outlined their research capabilities and interests, and delegates were given the opportunity to present their perspective on major R and D issues in their area of interest. These matters were brought together in group discussions to develop research directions and priorities. The program for the Water Workshop is presented in Box 1.

The workshop provided a platform for group discussions of the water-related issues in the Wet Tropics. It was targeted at managers and practitioners involved in the planning, design, implementation and management of water infrastructure development and rehabilitation in the region. Key personnel from the following organisations were invited (refer Box 2 for workshop delegates list).

- Department of Natural Resources (former) – now known as Department of Natural Resources and Mines (DNRM)
- DPI Fisheries
- Environmental Protection Agency
- Wet Tropics Management Authority
- Department of Main Roads
- Department of Local Government and Planning
- Local Authority regional representatives
- Catchment management agencies
- local consultants
- associated Rainforest CRC research Programs

WATER WORKSHOP PROGRAM

8.30 - 9.00	WORKSHOP REGISTRATION
9.00 - 9.30	**Welcome and Introductions**
9.00	Introductory remarks - *Ross Kapitzke*
9.05	Welcome to workshop - *Mike Berwick*
9.10	Workshop objectives - *Angela Arthington*
9.15	Introduction of participants - *Richard Pearson*
9.30 - 10.45	**Session 1 - CRC Overview of Research Capabilities and Interests**
9.30	Project 1.3 overview *Ross Kapitzke*
9.45	A planning and design framework for sustainable development and rehabilitation *Ross Kapitzke*
10.00	Whys and wherefores of environmental quality and ecological sustainability *Richard Pearson*
10.15	River ecology and environmental flows *Angela Arthington*
10.30	Fish ecology and riverine management *Brad Pusey*
10.45 - 11.15	MORNING TEA
11.15 - 12.30	**Session 2 – Delegates Presentations on R and D Areas of Interest**
11.15	'Healthy Waterways' for the FNQ region *Karen Benn, EPA*
11.30	Some priority R and D needs for management of waterways in the WTWHA *Max Chappell, WTMA*
11.45	DNR water planning *Peter Gilbey, DNR (DNRM)*
12.00	A physical stage for ecological restoration of Wet Tropics rivers *Errol Colman, DNR (DNRM)*
12.15	Main Roads - Issues and directions *Michael Frankcombe, MRD*
12.30 - 1.30	LUNCH
1.30 - 3.30	**Session 3 - Group Discussions to Develop R and D Directions and Priorities**
1.30	Group work: Break into three groups to discuss R and D topics under three themes for presentatiaon of suggested research projectss, scope, timing, costs, providers.
3.00	Group 1 presentation – *Water Quality*
3.10	Group 2 presentation – *Flow Management*
3.20	Group 3 presentation – *Infrastructure Issues*
3.30 - 4.00	AFTERNOON TEA
4.00 - 5.00	**Session 4 – Synthesis of R and D Directions and Priorities**
4.00	Overview of priority research projects and funding opportunities
4.30	Open discussion
5.00	Wrap up and close

LIST OF WORKSHOP DELEGATES

Stakeholders

Mike Berwick	Mayor	Douglas Shire	MOSSMAN
Karen Benn	Senior Conservation Offier	EPA	CAIRNS
Bruce Lawson	Principal Planning Officer	EPA	CAIRNS
Max Chappell	Manager Planning and Research	WTMA	CAIRNS
Steve Goosem	Senior Principal Scientist	WTMA	CAIRNS
Bruce Jennison	Principal Conservation Officer	WTMA	CAIRNS
Paul Bikaunieks	Senior Conservation Officer	WTMA	CAIRNS
Greg Underwood	Manager Strategic Planning	CCC	CAIRNS
Michael Frankcombe	Regional Environmental Officer	MRD	CAIRNS
Peter Gilbey	Manager Regional Infrastructure	DNRM	TOWNSVILLE
Errol Colman	Leader Water Resource Management	DNRM	STH JOHNSTONE
Alf Hogan	Senior Fisheries Biologist	DPI Fisheries	WALKAMIN
John Russell	Senior Fisheries Biologist	DPI Fisheries	CAIRNS
Sue Vize	Manager	NQAA	CAIRNS
Neil Boland	Environmental Scientist	NRA	CAIRNS
George Lukacs	Manager	ACTFR	TOWNSVILLE
Garry Werren	Research Officer	ACTFR	TOWNSVILLE
Steve Turton	Program 4 Leader	Rainforest CRC	CAIRNS
Anthony Forsyth	Honours Student	TESAG, JCU	CAIRNS

Rainforest CRC Project 1.3 researchers

John Patterson (apologies)	Head of School of Engineering	JCU	TOWNSVILLE
Richard Pearson	Head of School of Tropical Biology	JCU	TOWNSVILLE
Angela Arthington	Deputy Director CCISR	Griffith Uni	BRISBANE
Brad Pusey	Senior Research Fellow	Griffith Uni	BRISBANE
Ross Kapitzke	Senior Research Engineer	Engineering, JCU	TOWNSVILLE

Acronyms

EPA	Environmental Protection Agency
WTMA	Wet Tropics Management Authority
CCC	Cairns City Council
MRD	Department of Main Road
DNRM	Department of Natural Resources and Mines (was Department of Natural Resources)
DPI	Department of Primary Industries
NQAA	North Queensland Afforestation Association
NRA	Natural Resource Assessments
ACTFR	Australian Centre for Tropical Freshwater Ecology
CRC	Cooperative Research Centre
TESAG	Tropical Environmental Studies and Geography
JCU	James Cook University

CRC OVERVIEW OF RESEARCHER CAPABILITIES AND INTERESTS

This chapter includes the outcomes of the presentations by the CRC researchers John Patterson, Angela Arthington, Richard Pearson, Ross Kapitzke and Brad Pusey. A summary of each of the five presentations and related discussions is given.

RAINFOREST CRC PROJECT 1.3 (now 4.4) OVERVIEW

***Professor John Patterson**, Head of School, School of Engineering, JCU, Townsville*
***Mr Ross Kapitzke**, Senior Research Engineer, School of Engineering, JCU, Townsville*

Presentation

The overall objectives of Project 1.3 are to:

- provide guideline documents to assist practitioners and managers involved in infrastructure development or rehabilitation projects in rainforest environments
- combine engineering expertise and biological/ecological knowledge to establish an interdisciplinary basis and good practice methods for the planning, design, implementation and monitoring of projects.

The following R and D strategy is being followed in the initial phase of the project:

- provide for *conservation* of, *mitigation of impacts* on, and *rehabilitation of degradation* to significant environments of the Wet Tropics region (eg. streams within the WTWHA, streams adjoining the WTWHA, terrestrial rainforest habitats)
- deal with the effects on / by these *environments* from / on essential *infrastructure* such as linear corridors (eg. roads, powerlines, pipelines), water resource developments (eg. dams, weirs, extractions), stream rehabilitation (eg. alignment training, in-stream habitat restoration)
- develop *planning, design and implementation procedures* (eg. stream rehabilitation protocol), planning and design *tools* and *techniques* (eg. environmental flow evaluation), and understanding of *natural ecosystem processes* and *interaction with human use* (eg. infrastructure effects on stream habitat and biota)
- use an interdisciplinary approach involving *fundamental research* (eg. field studies), *applied research* (eg. case studies) and *technology transfer* (eg. publications, training workshops).

Progress to date includes:

- audit of significant environments, infrastructure types and locations, planning studies, and planning and design procedures is underway and a database of related literature is being compiled
- participation in river management planning exercises for the Barron River, Liverpool Creek, and Louisa Creek (Townsville), to be utilised to develop a protocol for stream redevelopment and rehabilitation planning and design
- pilot study on University Creek at JCU Townsville campus underway to develop remedial measures for barriers to fish migration at road culverts
- a manual on the ecology of freshwater fishes has been prepared for the former Land and Water Resources R andD Corporation (LWRRDC) and is now in revision for publication by the CRC/CCISR
- several review papers have been prepared on ecological methods for assessing the condition of streams affected by water infrastructure and flow regulation, water pollution and landuse change
- several projects relating to the effects of development on environmental quality and the ecological sustainability of streams are underway
- meetings have been held with Program 5 (Rehabilitation and Restoration) to identify opportunities for linking riparian restoration and water infrastructure research projects.

The presentation described progress on the audit of significant environments and infrastructure types, as it applies to planning and design procedures for development and rehabilitation projects.

By way of example, the presentation also outlined the project being undertaken in the School of Engineering at James Cook University to develop remedial fishways on several road culverts on campus that are restricting fish migration to important habitats. The fishway proposals have been taken to concept level design in preparation for laboratory model tests. The intention is to install and monitor performance of prototype fishways for these culverts, and examine application to other streams in the region.

Discussion

1. George Lukacs asked what are the cost benefits of culvert fishways?

   Ross Kapitzke advised that the intention was to develop simple designs to be used to minimise costs for retrofitting existing culverts. Perhaps these designs will be able to be applied to new culverts without a significant cost increase over the conventional hydraulic requirements.

2. Michael Frankcombe reported that the Main Roads Department conventionally looked at maintaining high velocities for flow capacity in culvert design, but are now looking at better designs for fish movement.

3. Errol Colman stated that culvert headwater levels and the concentration of floodwaters caused by culverts on floodplains are also important, not just discharge and velocity. It is desirable that culverts maintain sheet flow on the floodplains.

4. Richard Pearson inquired about the swimming speed of fish to be used in culvert design.

   Brad Pusey replied that some data on barramundi swimming speeds is available.

5. Mike Berwick suggested that there is a need to get the information to Councils and to provide guides for the engineers and operators. This is especially important for the Douglas Shire Council as they are due to replace many of their timber bridges.

6. Michael Frankcombe went on to say that the Main Roads Department found it is difficult to put culverts into active streams but now put bridges in wherever possible.

7. Alf Hogan reported that the NSW Fisheries are developing guidelines for culvert fishways.

8. Greg Underwood suggested that improved practices for local government should be implemented through the Queensland Urban Drainage Manual.

A PLANNING AND DESIGN FRAMEWORK FOR SUSTAINABLE INFRASTRUCTURE DEVELOPMENT AND REHABILITATION

***Mr Ross Kapitzke**, Senior Research Engineer, School of Engineering, JCU, Townsville*

Presentation

Practitioners and managers involved in infrastructure development and rehabilitation in tropical rainforests, face major challenges in achieving sustainability for these multipurpose projects. They must move beyond *legislation, policy, programs and management planning*, and the broad goals and visions for sustainability embodied in regional studies and strategic plans for natural resource management, to successful *planning, design and implementation* at the project level. A planning and design framework for infrastructure development and rehabilitation is useful here. Such a framework identifies the various planning and design elements involved in these projects, defines their inter-relationship, and provides a path for practitioners and managers to follow.

Although the types and the particulars of projects will vary, a common structure applies. This can be used to guide both *development* projects (eg. new roads, water storages, water extractions), where the goal is to *mitigate impacts* on the environment, and *rehabilitation* projects (eg. restoration of riparian corridors, in-stream habitat, terrestrial habitat), which aim to *improve the physical and biological condition* of degraded environments. We are dealing here with multipurpose outcomes, which must meet diverse and sometimes conflicting objectives. This contrasts markedly with conventional development projects, which for example, often had narrow goals emphasising economic values and human safety considerations, at the expense of ecological and cultural values. A framework for sustainable planning and design helps avoid these shortcomings.

The prevailing legislation, policy, and management regime is an integral part of an overall framework for sustainable development and rehabilitation. This includes *laws and regulations* (eg. Environment Protection Act), *policies and programs* (eg. Natural Heritage Trust), *institutional arrangements* (eg. Regional Organisation of Councils) and *management planning* (eg. FNQ 2010 Regional Plan). The key elements of the framework relating to project planning, design and implementation are:

- planning and design *procedures* (eg. spatial and temporal hierarchy)
- planning and design *tools* (eg. site prioritisation, alternative evaluation, flow benchmarking)
- development and rehabilitation *techniques* (eg. culvert fishways, fauna crossings)
- understanding of *natural ecosystem processes* and interaction with *human use* (eg. stream hydrology, disturbance ecology, impacts on aquatic biota)
- *guiding principles* (project phasing, multiple objectives, interdisciplinary approach)
- *linkages* between project participants and other stakeholders (consultation, extension).

The presentation illustrated the planning and design framework, and the procedures, tools, etc., through their application to stream redevelopment and rehabilitation. Reference was made to several collaborative research and development projects being undertaken through the School of Engineering at James Cook University. Clients in this work include the Land and Water Resources Research and Development Corporation, Natural Heritage Trust, Johnstone River Catchment Management Association Incoporated, and Townsville City Council.

Discussion

1. Max Chappell asked has the framework implementation started or not and is this regional or particular?

   Ross Kapitzke answered that he is proposing a generic framework for planning and design, which can be adapted to particular fields such as stream rehabilitation.

WHYS AND WHEREFORES OF ENVIRONMENTAL QUALITY AND ECOLOGICAL SUSTAINABILITY

Professor Richard Pearson, *Head of School, School of Tropical Biology, JCU, Townsville*

Presentation

Environmental quality refers to the physico-chemical environment (including traditional "water quality") and the biotic environment, which involves interactions among species, such as those that modify habitats. Several projects addressing this general theme are in progress at JCU, through the Australian Centre for Tropical Freshwater Research (ACTFR), and directly or indirectly linked to Rainforest CRC. These projects address important management issues, or provide the scientific background to allow us to address those issues. They include:

- flow requirements to maintain water quality, aquatic plants, invertebrates and riparian systems in groundwater-dominated stream systems (LWRRDC funded)
- development of water quality guidelines in tropical streams and estuaries (funded by EPA and Coastal CRC)
- impact of sediments on stream ecology (field and mesocosm-based experiments funded by LWRRDC and SRDC)
- impact of cane field drainage on stream ecology (field and mesocosm-based experiments on the impacts of low dissolved oxygen and nutrient enrichment, funded by SRDC)
- fish kills in the Wet Tropics (field surveys and laboratory experiments, funded by SRDC)
- water hole management in grazing lands (field-based experiments funded by the NHT and the Department of Defence)
- disturbance ecology and other natural processes in pristine streams (field experiments funded by the Rainforest CRC and ARC)
- impact of recreational activities on rainforest streams (field monitoring and experiments funded by the Rainforest CRC and the Commonwealth Tourism Department)
- biology of invasions by exotic fish species (field surveys and laboratory experiments funded by JCU).

This brief overview examined management objectives, assessed the level of research required in these and allied areas, and evaluated how far the listed projects go towards addressing the needs of management agencies, landholders and the community.

Discussion

1 Neil Boland questioned will you be developing toolboxes and procedures?

Richard Pearson replied that they plan to generate systems of techniques like New South Wales, but that they will be focused on our region.

2 Errol Colman commented that Richard's talk emphasised charismatic megafauna, which were said to be quite robust. Errol then questioned what is being done about understanding damage to less charismatic environments, which are not always so attractive to researchers?

Richard Pearson answered that fauna is in general quite robust in the southern Wet Tropics, for example, low oxygen levels are coped with better by animals in the southern than in central Wet Tropics region.

Brad Pusey confirmed this by saying that robustness is relevant in southern section of the Wet Tropics and that the north is more susceptible to disturbance.

RIVER ECOLOGY AND ENVIRONMENTAL FLOWS

Professor Angela Arthington, *Deputy Director, CCISR, Griffith University, Brisbane*

Presentation

Griffith University's contributions to Rainforest CRC research on freshwater ecosystems are undertaken via the Centre for Catchment and In-Stream Research (CCISR) in the Faculty of Environmental Sciences at the Nathan Campus in Brisbane, under four main R and D themes:

1. River and Riparian Ecology
2. Environmental Flows
3. River Health Assessment and Monitoring
4. Aquatic Conservation.

The main theme of the presentation was "River Ecology and Environmental Flows". Experience in these areas is diverse:

- ecology of streams, rivers and wetlands in coastal Queensland
- effects of flow regulation on stream ecology (water quality, fish, aquatic plants and riparian vegetation)
- methods for assessing the ecological condition of streams, and monitoring practices
- environmental flow methods and best practice.

The following presentation by Dr Pusey outlined fundamental research on the ecology of streams and rivers with particular emphasis on freshwater fishes, and the importance of this information as part of the scientific foundation of river flow management, habitat restoration and aquatic conservation. Angela outlined key R and D opportunities that would be consistent with the information needs of WTMA, the Departments of Natural Resources and QDPI Fisheries, the EPA, local government, industry and tourism.

- Natural flow regimes and the effects of water resource development
- Hydrological descriptions of regulated flow regimes of relevance to ecological processes
- Predictive models of relationships between hydrological descriptors and ecological processes
- Methods of assessment of impacts of water regulation in relation to other types of stress (eg. landuse)
- Improved methods and Best Practice for environmental flow determinations and management
- Tools for monitoring and analysis of the ecological outcomes/benefits from flow and in-stream habitat restoration
- Environmental Best Practice in the Wet Tropics
- Information packages for managers and community groups.

Much of this research can be undertaken through various forms of collaborative arrangement between CRC researchers from the partner organisations. This is already happening in a number of ways on existing projects, including staff exchange and acquisition of equipment. Postgraduate training is an important part of our collective mission as Rainforest CRC researchers, and joint supervision between institutions is a benefit of the CRC worth developing further. An ideal collaborative arrangement might involve the ecological and engineering skills of the two Universities.

Finally, the Griffith University team is actively engaged in collaborative work within the Water Resource Plan program of the Department of Natural Resources and Mines (eg. Fitzroy, Barron and Pioneer WAMP/WRPs) and we look forward to further opportunities to apply the outcomes of our research in river flow planning and management.

Discussion

1. George Lukacs asked what is meant by preservation – the first management option presented by Angela Arthington?

   Angela replied that not enough reserve systems exist and we cannot restore all rivers so we should prioritise what we should and can preserve now.

2. Ross Kapitzke inquired what do you mean by active management – the second manage ment option?

   Angela said for example, modifying dam releases to minimise downstream impacts, stocking fish and improving water quality. This is the step before rehabilitation so it is less demanding.

3. Ross then asked where does mitigation of new developments fit in?

   Angela replied that this is part of active management.

4. Richard Pearson suggested that there is a need to nominate a hierarchy of streams in order from pristine to degraded.

   Brad Pusey continued by saying that in trying to rank rivers, some will have a low score such as the Barron, but the Barron is important for frogs. Trying to lock rivers up in re serves needs clever management.

   Angela re-emphasised the need to develop conservation priorities straight away.

   Max Chappell went onto say that catchments may not be representative, but WTMA needs priorities urgently to implement active management. This is a huge task both politically and practically when prioritising works but how we get to that should be a priority for discussion today.

5. Miriam Goosem questioned what are the monitoring protocols?

   Brad answered that they are still working on methods for collecting data when using fish as tools. A Griffith University PhD is underway to explore key issues.

FISH ECOLOGY AND RIVERINE MANAGEMENT

***Dr Brad Pusey**, Senior Research Fellow, Griffith University, Malanda*

Presentation

Within the four major themes of 1) River and Riparian Ecology, 2) Environmental flows, 3) River Health Assessment and Monitoring and 4) Aquatic Conservation outlined by Professor Arthington, a series of research programs has been running for the past decade and a half which strongly focus on freshwater fishes.

These programs have included:

- studies of the distribution and habitat requirements of fishes in a diverse range of habitat types including lakes, reservoirs, swamps, wetlands, and sub-tropical and tropical rivers. More recently, quantitative data on the density and biomass of species, plus detailed habitat descriptions, have been collected for over 400 sites in the Wet Tropics region and south-eastern Queensland
- studies on feeding ecology and trophic relationships of freshwater fishes in several of the above habitats. Much of this information has been assembled in a nationwide review of trophic ecology of freshwater fishes as well as a forthcoming book on the ecology and management of Queensland's freshwater fishes
- studies examining biogeographic and evolutionary aspects of speciation of the fauna as well as more basic taxonomic research resulting in the description of new taxa
- studies undertaken by the group aimed at defining and understanding the life histories of individual species as well as quantifying the seasonal dymamics of larval fish production and the habitat requirements of larval fish.

The research program has always been aimed at addressing questions of an ecological nature. However, such information is invaluable, and has already proved to be invaluable, in addressing questions relating more to management. For example, information on the distribution of fishes in the WTWHA was critical in defining the recent conservation value of waterways in the World Heritage Area. Similarly, these data are invaluable for developing predictive relationships between species or assemblages and their habitat, which can be used in environmental flow assessments or as guidelines for environmental restoration. Such data can be used to define the boundary conditions for effective monitoring of aquatic habitats and the use of fishes as environmental indicators, and the correct way of collecting, describing and reporting on the condition of fish assemblages.

The presentation discussed the various uses to which the data sets can be used to aid management in the Wet Tropics region and other areas such as Cape York, central Queensland and south-eastern Queensland. This relates particularly to environmental flow management, rehabilitation and restoration, identification of rare and threatened taxa (particularly genotypes and disjunct populations) and public awareness and education programs. The presentation also introduced some of the material being produced by the group to assist agencies, conservation groups and researchers. In addition, the presentation highlighted those areas needing to be addressed by a continued research effort.

Discussion

1 Max Chappell asked what the requirements were for stream conservation on the coast?

Brad replied, for example, the Maccullochs Rainbow fish requirement for survival is high, as a majority have gone from the Barron catchment as a result of the wetlands being reduced (only 25% left). This Rainbow fish is an example of the hammering wetland fish have taken but a lot more survey work and sampling should be done to determine its status.

DELEGATES PRESENTATIONS ON RESEARCH AND DEVELOPMENT AREAS OF INTEREST

This chapter includes the outcomes of the presentations by stakeholder delegates from the Environmental Protection Agency, Wet Tropics Management Authority, the former Department of Natural Resources (now DNRM) and Department of Main Roads. A summary of the five presentations and related discussions is given.

HEALTHY WATERWAYS FOR THE FNQ REGION

***Ms Karen Benn**, Senior Conservation Officer, Environmental Protection Agency*

Presentation

Overview of* Healthy Waterways – *What does it offer?

No single organisation can deliver the actions and funding required to maintain and improve our waterways. Assistance and support will need to come from all levels of community, industry and government. For this reason, an inclusive badge has been developed in SEQ to represent all the work that is required across the catchments in that planning region. That new badge, *Healthy Waterways* has been developed as a cooperative badge with its own distinctive logo. It can be used by all stakeholders to give a clear, single focus to all the actions being taken now and into the future with regard to planning and management of waterways.

Stakeholders can use the logo beside their own brand or identity or logo to demonstrate to the community and other stakeholders that they:

- understand the issues
- are aware of what needs to be done
- work in a cooperative manner with other stakeholders to achieve a collective vision
- are aware that “we’re all in the same boat”
- choose to be “crew members”, not just passengers along for the ride.

The overall aim of the *Healthy Waterways* cooperative badge is to inspire and remind all elements of community, government and industry to take continued action to protect and enhance the waterways of the region. The goal is to provide the necessary information, education and **coordination** and to deliver the vision. The shared vision in SEQ is:

Our catchments and waterways will be healthy ecosystems supporting the livelihoods and lifestyles of people in Queensland, and will be managed through collaboration between community, government and industry.

A community information and education campaign has been developed to address the delivery of the *Healthy Waterways* vision. The structure is a key to the delivery of successful coordination of water management in SEQ. This structure facilitates the transition of scientific findings and community and agency information into well supported management decisions.

Healthy Waterways *Potential for Far North Queensland*

The mission is to develop a similar structure for a comprehensive water quality strategy for the catchments of Far North Queensland, which will provide details on how the waterways should be managed to achieve the vision, and which will be based on:

- sound technical understanding
- recognition of community values
- cooperative and integrated approach brought about by partnership arrangements with different levels of government bodies, community and industry.

FNQ has the potential to use the SEQ type of structures, materials, information, techniques and experience to adapt to this region to suit its own needs, and to simultaneously deliver the aims and objectives of a wide range of planning schemes and instruments. This includes the FNQ Regional Plan, the Regional Coastal Management Plan, National Strategy for ESD, Natural Resource Management Strategy for FNQ, Barron WRP, ICM Plans and more.

Discussion

1 Michael Frankcombe asked what does the Healthy Waterways program do in this area?

Karen Benn replied that Mike Berwick plans to back it but needs the support of the Cairns City Council. This approach brings the community into the picture, led not by the Environ mental Protection Agency, but by the councils. Brisbane City Council will help where needed. There is no budget in the EPA for implementing Healthy Waterways.

2 Greg Underwood inquired does this project require new monitoring?

Karen answered that there will be some new initiatives but existing ones will also be used. Snapshots are created for good interpretation where the issues are obvious. In SEQ, all councils are involved, local authorities are central to the program and communicating the program using good graphics is important.

3 Greg suggested not to politicise it, and the Cairns City Council will embrace the issue.

4 Karen advised that the scenario was similar to the Trinity Inlet Management Plan (TIMP) charter.

5 Errol Colman stated that funding for baseline research and coordination will be required and that the Brisbane City Council is the main contributor in south-east Queensland.

6 Angela Arthington advised that protocols for evaluating healthy waterways using fish have been developed and the data are available to extend these techniques into north Queens land systems. Some development of models predicting fish present in healthy streams will be needed.

SOME PRIORITY RESEARCH AND DEVELOPMENT NEEDS FOR MANAGEMENT OF WATERWAYS IN THE WTWHA

***Mr Max Chappell**, Manager Planning and Research, Wet Tropics Management Authority*

Presentation

WTWHA is a significant natural area within the WT bioregion.
WTMP regulates disturbance to waterways within WHA but generally allows existing water extraction operations (ie operating at the time of introducing the WTMP) to continue.

Current Approach to Management:
Development of Water Infrastructure in the Wet Tropics Guidelines which includes information concerning which watercourses are most likely to be impacted by flow regulation or which contain taxa of special conservation value or interest.

Key Management Issues for WTMA:

Existing Infrastructure:

- 24 existing community water supplies (2 for hydro-electricity) within WHA
- management interest associated with ongoing impacts resulting from abstraction regimes, physical structures and fragmentation of riparian corridors
- **R and D needs** include development of best practice to mitigate ongoing impacts through development of appropriate environmental flow regime guidelines for key water supplies in WHA, best practice design for culverts and approaches, and design guidelines for riparian corridors, eg. optimal widths to achieve ecological function requirements, WT regional examples of in-stream ecosystem benefits derived from riparian repair (eg tree planting).

New Infrastructure potential:

- Upper Herbert
  - **R and D needs** include environmental flow requirements of Herbert River and best practice dam design to accommodate preferred environmental flow regime requirements
- Tablelands groundwater
  - **R and D needs** include understanding of the role of aquifers in ecology of WHA streams, and implications of water extraction on WHA streams.

Rainforest stream ecosystems, pigs and people

- both visitor and pig activity is concentrated along waterways, roads and walks
- **R and D needs** include potential impacts on stream ecology resulting from visitor activity and pig activity; a comparative assessment of impacts between visitors and pigs; and identification of stream characteristics which predispose streams to such disturbances.

Headwater modifications in otherwise pristine sub-catchments

- some streams of WTWHA are ‘pristine’ waterways except for isolated pockets of neighbouring lands
- **R and D opportunity** exists to undertake research and directly assess impacts of such specific individual land use activity on otherwise undisturbed WT aquatic systems.

Discussion

1 George Lukacs stated that the potential impact of tableland waterways on the World Herit age Areas is not understood. This Researchers and managers need to look at tableland scale impacts and not just flow effects within the WHA.

DNRM WATER PLANNING

Mr Peter Gilbey, *Manager Regional Infrastructure, DNRM*

Presentation

This talk examined water planning aspects introduced in the *Water Act 2000* and discussed R and D requirements identified in the Barron River WRP process.

The *Water Act 2000* addresses deficiencies in the *Water Act 1989*, which made no provisions for the environment and gave poor security for water users. The new act adopts a holistic approach to water planning at three levels:

- catchment level, through water resource plans
- run of river reach, through resource operation plans
- property level land and water plans.

The following priority research areas were identified for environmental flow requirements within the Barron, Upper Walsh and Upper Mitchell Catchments:

- environmental flow management strategies
- benchmarking of riverine health
- water use efficiency modelling
- impact of interbasin transfers
- channel morphology requirements
- water quality modelling
- community metabolism
- riparian and aquatic vegetation requirements
- macroinvertebrate, crustacean and freshwater fish requirements
- climate and land use change.

The presentation discussed the priority and need for this basic data, together with the need for development of accepted evaluation methodologies for determining the level of change from natural that is allowable without impacting on biodiversity. The manner in which the (former) Department of Natural Resources guides others on appropriate measures for intervention with riparian areas was also described. This may involve information on sustainable land use and vegetation management, and could apply where catastrophic failure of infrastructure due to channel avulsion is to be avoided.

Discussion

1 Ross Kapitzke asked whether the new Water Act 2000 encompasses catchment management and rehabilitation?

2 Peter Gilbey replied that the Act has a strong planning component. DNR (now DNRM) will set up planning teams to deal with particular issues. These teams may include CRC personnel.

A PHYSICAL STAGE FOR ECOLOGICAL RESTORATION OF WET TROPICS RIVERS

***Mr Errol Colman**, Leader Water Resource Management, DNRM*

Presentation

In the mad rush to spend a sizeable proportion of Telstra in an "all-singing, all-dancing" ecologically biodiverse and sustainable rainforest show which was how the Natural Heritage Trust production emerged, we North Queenslanders overlooked a few very basic rules of stagecraft. Now that the dust is settling on NHT and some reviews are far from complimentary, it is worthwhile to indulge in the wisdom of hindsight before we stage our next now sadly low budget production.

For example, whilst visions abounded of stunningly wide swathes of bio-diverse riparian vegetation sprouting miraculously from the floodplain, and we discussed *ad nauseum* the finer points of this or that rainforest species, we totally ignored the fact that the public didn't own the land on which all this was to happen. We forgot to book the theatre in other words and the often vertical and always too narrow space between the top of the river bank and the water which was the only stage we could reliably acquire, proved to be totally inadequate for such an ambitious "cast of thousands" production. At most we created a continuous edge effect.

Unfortunately we also failed to recognise that the ambience of the substitute stage also bore little resemblance to the ambience required for the type of production we had planned. For whilst the desire to emulate a pristine pre-European settlement type of rainforest ecology was very strong, we studiously ignored the reality that the rivers as we know them were now fundamentally different in a physical sense to those which existed pre-settlement. In fact, order of magnitude changes had occurred to almost all of the basic physical parameters, which define the nature of the watercourses since settlement. These physical changes were almost invariably a symptom of the replacement of the rainforest on the floodplain with a predominance of exotic grass species. Such physical parameters which were radically changed include the rate of cross-floodplain migration, the drainage and sediment moduli, and the natural levee reformation/avulsion rates to name a few.

So instead of a narrow, deep, slowly migrating channel flanked on both sides with continually reforming natural levees permitting occasional avulsions, the show went ahead on a wider, shallower rapidly migrating sediment and grass choked channel with frequent avulsions, since levee reformation was almost non-existent. It is little wonder then that the remnant rainforest ecology was highly impacted and vulnerable and that the highly constrained attempts at rainforest based ecological restoration languished pathetically on the rivers.

So before we embark on the next suite of ecologically focussed rainforest research projects it is respectfully suggested that a moment's consideration be given to properly securing the following essential physical elements for the show:

a) The economic, social and legal mechanisms for acquiring the riparian land as a public asset (remember to book a suitable stage this time).
b) The pre-settlement nutrient, sediment and drainage moduli and how to artificially emulate those on a grass covered floodplain striated with transport infrastructure (choose a stage with the right ambience for the production in other words).
c) The pre-settlement cross floodplain migration, natural levee formation and avulsion rates and how to emulate that on the same grassy floodplain (choose a stage with the right dynamics).
d) The nature of grassland/forest edge effects and how to artificially minimise these impacts (or how to best stop the ambient traffic noise from spoiling the show).

Without these fundamental elements of stagecraft we may well be better advised to stage an exotic grassland rather than attempt another rainforest production this time.

Discussion

1 Ross Kapitzke noted that Errol Coleman mentioned the importance of understanding and emulating pre-development conditions in restoration. Ross went onto say that this is hardly achievable in most situations, but we should not consider a dichotomy of either complete restoration or wiping our hands of it. Sustainability entails human development and intervention that works with the natural system, for example, stream infrastructure that recognises the dynamic nature of streams in their natural and altered states.

2 Errol added that loss of trees changes the magnitude of channel change, and that ecological restoration needs guiding parameters relating to these changes to create a thriving ecologica system.

MAIN ROADS - ISSUES AND DIRECTIONS

***Mr Michael Frankcombe**, Regional Environmental Officer, Department of Main Roads, Cairns*

Presentation

With increasing community environmental awareness and expectation, and an ever more rigorous regulatory environment, Main Roads faces new environmental challenges on a daily basis. Some of the emerging issues in the North Queensland Region include:

- water quality from bridge and road runoff
- rehabilitation of disturbed areas with endemic species particularly in the WTWHA
- effective management of weeds in the road corridor
- noise emissions from urban roads
- sediment basin design
- the movement of fauna through the road corridor, particularly with respect to icon species such as the cassowary and tree kangaroo
- the preservation of riparian corridors.

This presentation examined these environmental issues, discussed some of the solutions and looked at what research is required to find a way forward.

Discussion

1 Errol Colman asked does the minister know about this presentation and the environmental degradation that you have depicted, and also inquired if there was legislation in place that can be used to broaden the focus of those responsible for building roads?

2 Peter Gilbey stated that there is a need to highlight the way things can be done best. Information is available, for example, the *Stream Stabilisation for Rehabilitation* book prepared by JCU. Peter also suggested that regional designers need to talk to groups like this group.

3 Alf Hogan suggested that these issues and the solutions should be brought to the attention of undergraduate students. He was prepared to contribute to engineering courses.

4 Richard Pearson asked how is the money given out for research? Michael Frankcombe replied that the Main Roads Department has reponded to individual R and D applications.

5 Max questioned is there a possiblility of making Best Practice manuals? Michael answered that we are putting things like this in place, for example, the Drainage Design Manual.

WATER RESEARCH PLAN

Following the Water Workshop presentations by CRC researchers and stakeholders, delegates were separated into three groups to discuss R and D directions and priorities under the following themes:

- Water Quality
- Flow Management
- Infrastructure Issues.

The group discussions provided major input into the *Research priorities for conservation and managment of freshwater resources in the Australian Wet Tropics: Water Research Plan* subsequently developed by the research team. In developing the *Water Research Plan*, workshop discussions and outcomes were synthesised, taking into account key planning documents, including *The Wet Tropics Information Needs for Management* (WTMA 2000) and the *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999).

The *Water Research Plan* is summarised in Figure 1. The overall CRC research project, originally entitled *Project 1.3 – Project Designs for Essential Infrastructure*, incorporates a number of research sub-projects, numbered here as 1 to 6. The details of each of these projects are provided in Appendices A – G, with administrative and budget details removed, as these are likely to change closer to the date of commencement of most projects. Running in parallel with the other major collaborative research projects (1-5), we propose a best practice case study focused on the Mulgrave River (Project 6). The *Water Research Plan* also identifies a number of emerging topics offering opportunities for CRC researchers to establish new initiatives, according to stakeholder needs and funding opportunities.

As shown in the *Water Research Plan*, the major outputs of the research program are guidelines and training materials for best practice water management in the Wet Tropics, covering three major areas:

- Infrastructure Design in Rainforest Catchments
- Provision of Environmental Flows in Rainforest Streams
- Maintenance and Restoration of Rainforest Stream Ecosystems.

The program is designed as a collaborative and integrated research agenda for the CRC over a 3 to 5 year timetable. It is well supported by stakeholder groups, with sustainable infrastructure designs, water conservation and water supply recognised as some of the critical issues for present management and future development. The research team comprises University and CRC staff who are sought after by relevant agencies (especially DNRM) for their expertise in river management. In addition to research project funding from several industry sources, in-kind support is provided by agencies and consultants through the participation of project team members in collaborative research and consulting projects directly related to the objectives of CRC research.

The *Water Research Plan* includes three main inter-related components, representing the three research groups involved – the Griffith University ecology group led by Prof. Angela Arthington, the James Cook University ecology and water quality group led by Prof. Richard Pearson, and the JCU environmental engineering group, led by Prof. John Patterson.

Elements of the *Water Research Plan* have been funded for 2001/2002 and are now incorporated into CRC Research *Program 4 – Rainforest Access: Managing and Monitoring Impacts*, under the new research project title *Project 4.4 - Water Resources: Ecology and Management*. The relocation to Program 4 was undertaken to help ensure (i) that there is complementarity rather than overlap between the two CRC programs that deal with infrastructure and impacts, and (ii) that the appropriate expertise is being applied to such projects. Major tasks in Program 4 water research are outlined on the CRC's Web site <www.rainforest-crc.jcu.edu.au>.

RESEARCH DIRECTIONS 2001-2002

Project 4.4 will focus substantial effort on production of outputs from previous research during 2001/2002 (Table 1). Some CRC funding will be used to maintain or establish vital new research and to ensure that on-going CRC funded and new externally funded research will not lose momentum.

Table 1 Research outputs expected in 2001/2002

Output	Output type	*Project Team	Timetable for Submission
Report on Water Workshop – R and D Needs for Water in the Wet Tropics	CRC tech report	RK, AA (Eds)	Dec 2001
Annotated Bibliography of Planning and Management Guidelines	CRC tech report	RK, JP, AA, RP, BP	June 2002
Annotated bibliography of stream process and condition data for north-east Queensland	CRC tech report	RK, AA, RP, BP	June 2002
Stream rehabilitation training workshop for practitioners and managers	Training workshop	RK, RP	June 2002
CRC Monograph on Biology and Environmental Flow Requirements of Queensland Freshwater Fishes	CRC Monograph	BP, AA, Kennard	June 2002
Guide to monitoring stream health using macroinvertebrates	CRC tech report	RP	March 2002
Rapid biophysical assessment of stream condition	CRC tech report	RP, AA, BP, Werren	June 2002
Report on workshops – Recreation and Water Quality	CRC tech report	RP, Butler	March 2002
Report on aquatic plants of the Mulgrave River	CRC tech report to WTMA	GW, BP, AA, Cairns	June 2002
Determinants of freshwater fish biodiversity in rivers of north-eastern Australia	Journal article, *Hydrobiologia*	BP, AA, Kennard	Feb 2002
Distribution of freshwater fish in north-eastern Australia: landscape filters in multiple catchments	Journal article, *Ecology of Fresh -water Fish*	BP, AA, Kennard	June 2002
Assessing the biodiversity of freshwater fishes: considerations at various spatial and temporal scales	Journal article, *Marine and Fresh -water Research*	Kennard, BP, AA	June 2002
Utility of the RIVPACS modeling methodology for prediction of freshwater fish assemblages and detection of anthropogenic disturbance	Journal article *Freshwater Biology*	Kennard, AA, BP	Dec 2001
Spatial variation in the distribution and abundance of submersed aquatic macrophytes in an Australian subtropical river	Journal article *Aquatic Botany*	Mackay, AA Kennard, BP	Dec 2001
Report on Benchmarking Methodology for Environmental Flow Assessments	DNR&M and Griffith Uni Tech Report	Brizga, AA, BP, Kennard, Mackay, Werren	June 2002
Responses of invertebrate communities to low dissolved oxygen concentrations in Wet Tropics streams	Journal *Freshwater Biology*	RP, Connolly, Crossland, Butler	March 2002
Responses of selected fishes to low dissolved oxygen concentrations in Wet Tropics streams	Journal article *Freshwater Biology*	RP, Connolly, Crossland, Butler	March 2002

Responses of invertebrate communities to high suspended sediment loads in Wet Tropics streams	Journal article *Marine and Fresh -water Research*	RP, Connolly, Crossland	June 2002
Impacts of deforestation on stream ecology In: Forests - Water -People in the Wet Tropics	Monograph article (Ed. Bonell)	RP, Connolly	Jan 2002
Effects of nitrate and phosphate enrichment on forest stream ecology	Journal article *Freshwater Biology*	RP, Connolly, Crossland	June 2002
Water quality of Wet Tropics streams	Journal article *Marine and Fresh -water Research*	RP, Butler	April 2002
Evolution and systematics of leptophlebiid mayflies	PhD thesis	Christidis (Pearson)	July 2002
Ecology of stream-dwelling chironomids	PhD thesis	McKie (Pearson)	Feb 2002

*AA = Angela Arthington, BP = Brad Pusey, JP = John Patterson, RK = Ross Kapitzke, RP = Richard Pearson

ON-GOING RESEARCH

The project team is committed to pursuing on-going and new research during 2001-2002 because to call a complete halt to new research at this stage would lead to irreparable damage to the overall CRC water research project. This project builds on earlier research, and introduces new tasks relevant to appropriate management of streams in the Wet Tropics. Tasks on the research agenda and their proposed status for the coming year are outlined in Table 2.

Table 2 Ongoing research tasks

Task	***Project Leaders**	**Project-funded Staff**	**Status 01-02 (assumes minimal funding)**
R & D Needs and Infrastructure Audit	JP, AA, RP	Kapitzke	To be completed
Stream rehabilitation protocols and techniques	JP, AA, RP	Kapitzke, Pusey, Connolly	On-going
Culvert fishway laboratory model and prototype	JP, RP	Kapitzke, Patterson, Pearson	On-going (supported by Main Roads Dept 01-02)
Road drainage, waterways and fauna crossings	JP, AA, RP	Kapitzke, Butler	Dependent on level of funding (e.g. Main Roads). Seeking external funding for post-grad student
Environmental quality and ecological sustainability	RP, JP	Connolly, Crossland, Butler, Kapitzke	On-going; partly funded by SRDC
River ecology and environmental flows	AA, RP	Pusey, Connolly, Werren	Fish work continuing (AA , Pusey); Invertebrate work subject to funding (RP, Connolly)
Best practice management: Mulgrave River case study	AA, JP, RP	Pusey, Kapitzke, Connolly, Werren	Seeking CRC start-up funding for 2001-2002. Workshop April 2002.
Recreation and water quality	RP, AB	Butler *et al.*	Phase 2 to be completed; new developments subject to funding

*AA = Angela Arthington, BP = Brad Pusey, JP = John Patterson, RK = Ross Kapitzke, RP = Richard Pearson

Emerging topics: • Water storage development and management • Interbasin transfers • Salt intrusion in wetlands • Wetlands ecology and management	On agenda for future research, funding to be sought as opportunities arise

APPENDICES

APPENDIX A - PROJECT 1 DESCRIPTION

Title Water Research and Development Needs and Infrastructure Audit

Key researchers I. R. Kapitzke (JCU), J.C. Patterson (JCU), R.G. Pearson (JCU), A.H. Arthington (GU), B.J. Pusey (GU)

Duration **Start** 07/99 **End** 06/01

Background/ Relationship to CRC and Program goals

Water is a dominant element of tropical rainforests, and an understanding of water related issues is critical to the Rainforest CRC's mission to support sustainable use, management and conservation of these forests in Australia. The *Wet Tropics Information Needs for Management* (WTMA 2000) and the *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999) have each identified priority areas for research and development in water-related topics in the region. These water-related topics generally involve infrastructure with the WTMA plan giving a high priority to linear corridors.

The effects of essential infrastructures on significant environments are also important for the sustainable use of the tropical rainforests. For example, linear corridors (roads, powerlines, pipelines), water resource developments (dams, weirs, extractions), materials extractions (sand and gravel) and stream rehabilitation (alignment training, in-stream habitat restoration) impact on significant environments of the Wet Tropics region such as streams within the WTWHA, streams adjoining the WTWHA, and terrestrial rainforest habitats.

Sustainable use of the Wet Tropics region requires the conservation of, mitigation of impacts on, and rehabilitation of degradation of these environments. To achieve sustainability, practitioners and managers involved in water and infrastructure projects in the region require a suite of planning, design and implementation procedures (eg. stream rehabilitation protocol), planning and design tools and techniques (eg. environmental flow evaluation), and understanding of natural ecosytem processes and interaction with human use (eg. infrastructure effects on stream habitat and biota).

A review of water and infrastructure issues is an essential first step in developing these products. The intention is to prepare a *Water Research Plan* for water in the water in the Wet Tropics, and to conduct an audit of infrastructure types and issues. This sub-project forms an essential part of Project 1.3, setting the direction for research in the other sub-projects.

Potential applications of the research

The major outputs from this sub-project, the *Water Research Plan* and the *Infrastructure Audit,* will identify relevant issues for the Wet Tropics region and will provide a focus for research activities in the rest of the project. These products will also provide a basis for collaborative research programs in various areas with agencies such as the departments of Natural Resource and Main Roads.

The main potential application of this research for stakeholders will be defined planning and design procedures, tools and techniques for infrastructure design and development within and around the Wet Tropics region. It will assist in determining the infrastructure types and significant environments critical for sustainable development and rehabilitation practices. The audit of planning and design procedures will provide a base from which to develop the appropriate planning and design procedures for use by practitioners and managers in infrastructure planning and design within the Wet Tropics.

Objectives

The objectives of this sub-project are to:

- identify major water R and D issues for stakeholders and their relationship to the capabilities and interests of CRC researchers
- identify those environments in the Wet Tropics region having critical conservation values that may be affected by infrastructure developments
- identify critical issues for sustainability relating to water and infrastructure, and identify relevant planning and design procedures, tools and techniques presently in use
- identify gaps in present knowledge relating to water and infrastructure issues
- determine priorities for research and development, and identify funding options
- compile outcomes for circulation to stakeholders, and within the CRC.

Outputs

The outputs of this sub-project are:

- An R and D Workshop for Water in the Wet Tropics involving the appropriate stakeholders (completed October 2000)
- The *Research priorities for conservation and management of freshwater resources in the Wet Tropics: Water Research Plan* outlining the major issues and priorities for the Wet Tropics region (due June 2001)
- The *Audit of Significant Environments and Infrastructure Types in the Wet Tropics*, identifying the significant environment and infrastructure types in the Wet Tropics, and including an annotated bibliography of planning and design procedures for infrastructure design (due June 2001).

Linkages/ Collaborators

Other project type	Nature of linkage
Within CRC	Links with Program 1 groups and Program 4 through water workshop, PSGs, review of technical issues etc
Other	Participation in R&D Workshop on Water by key agencies (eg. DNR and MRD) Collaborative research with MRD, DNR, river trusts etc identifying R & D needs and priorities

Who are the key stakeholders?

The following stakeholders are involved in the research project through participation in workshops, consultations and other collaborative activities:

- Wet Tropics Management Authority
- Environmental Protection Agency
- Department of Natural Resources (now DNRM)
- Department of Local Government and Planning
- Main Roads Department
- Department of Primary Industries
- Local Authorities
- North Queensland Afforestation Association
- Catchment Coordinating Committees
- River Improvement Trusts
- Canegrowers
- Consultants (eg Natural Resource Assessments).

Research strategy and proposed methods

This sub-project is comprised of two components - Water R and D Needs and Audit of Significant Environment and Infrastructure Types. These products both set the direction for the other sub-projects

in Project 1.3. The approach for this sub-project involves consultation, review of literature and compilation of relevant information. Many contacts have been made with key stakeholders to identify the major issues and procedures. As this is an on-going process, more consultation with these stakeholders and others will be undertaken in the course of the research Program.

The method for determining the R and D Needs for Water in the Wet Tropics was to conduct a Workshop, which was held in Cairns on 24 October 2000. This workshop provided the ideal opportunity for presentations and discussions with a broad range of stakeholder groups. It is leading to the endorsement of a research plan for the water-related components of Project 1.3 through the publication of an R & D Plan from the discussed topics. These topics to be included in the R & D Plan as a result of the workshop include stream rehabilitation protocols and treatments; road drainage, waterways and fauna crossings; environmental quality and ecological sustainability; and river ecology and environmental flows. A number of other emerging topics relating to water storages, salt intrusion etc. have been identified. The *Water Research Plan* will document the proposed research activities, which will deliver outcomes in the short, medium and long-term. These will be built on individual areas of expertise but will be integrated within the broad themes of Guidelines for Maintenance and Restoration of Rainforest Stream Ecosystems, Guidelines for Infrastructure Design in Rainforest Stream Ecosystems, and Guidelines for Provision of Environmental Flows in Rainforest Streams.

The Audit will identify significant environments, infrastructure types and locations, planning studies, and planning and design procedures relevant to infrastructure development and rehabilitation in the wet tropics bioregion. The Audit reviews practices and knowledge of particular infrastructure types, and asks: what are the issues of interest, what is presently in place, who is doing what, what is the present knowledge base, and what are the knowledge gaps. This information is used in the development of the research plan, which will address procedures and techniques for use by practitioners and managers in the planning and design of these infrastructure projects as well as identifying principle issues and areas of concern.

The information to conduct the Audit was acquired from literature on significant environments, infrastructure types and planning and design procedures. This included reviewing the conservation priorities for the region from WTMA, NRA and ACTFR reports as well as legislation, policy and planning studies such as the Wet Tropics Management Plan and FNQ2010 Regional Plan. Current major water, road and other projects in the region such as Atherton Tableland / Cairns Region Water Study, Barron River WRP and Kuranda Range Integrated Transport Study, and planning and design guides and procedures such as QESI Electricity Code, WTMA Codes of Practice, Roads in the Wet Tropics and Road Design Environmental Process manual were also reviewed.

Consultations were also held with infrastructure planning engineers from DNRM, Queensland Government planners, environmental engineers and environmental scientists from MRD, stream management agency personnel, local authority resource and infrastructure managers, consultants and others.

The approach taken here is to:
- identify those environments in the Wet Tropics region having critical conservation values that may be affected by infrastructure developments
- overlay major infrastructure on this to identify principal issues and areas of concern
- identify critical issues for sustainability relating to various infrastructure types
- identify revelant planning and design procedures, tools and techniques
- identify knowledge gaps and research priorities.

The research strategy is to:
- provide for conservation of, mitigation of impacts on, and rehabilitation of degradation to significant environments of the Wet Tropics region
- deal with the effects on / by these environments from / on essential infrastructure such as linear corridors, water resource developments and stream rehabilitation

- develop planning and design procedures, planning and design tools and techniques, and an understanding of natural processes and interaction with human use
- use an interdisciplinary approach involving fundamental research, applied research and technology transfer

Work Plan

	99/00				00/01				01/02				02/03			
Task	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Workshop						XX	XX	XX								
Synthesis of workshop discussions									XX							
Water R&D Plan									XX	XX						
Review of literature for audit		XX	XX	XX	XX	XX	XX	XX								
Consultation with stakeholders		XX	XX	XX												
Audit Report									XX	XX						
Stakeholder review of R & D Plan and Audit Report														XX	XX	

Milestones

Milestone	*Due date for completion*
Workshop: researchers and managers to develop infrastructure research portfolio	10/00 03/01
Synthesis of workshop discussions	06/01
Water Research Plan	12/00
Review of literature for the audit	12/99
Consultation with relevant stakeholders on the audit	06/01
Audit of significant environment and infrastructure types	12/01
Stakeholder review of Research and Development Plan and audit report	

Communication plan

Stakeholders attended the workshop in Cairns in October 2000 to discuss the R & D issues relating to water in the Wet Tropics. Stakeholders have also been consulted on the Infrastructure Audit. A draft *Research priorities for conservation and management of freshwater resources in the Wet Tropics: Water Research Plan*, and *Infrastructure Audit* will be circulated for stakeholder input and comment prior to finalisation. The finalised *Water Research Plan* will be submitted to the CRC in 2001, with appropriate recommendations for implementation and resourcing.

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Wet Tropics Management Authority 1997 *Protection Through Partnerships: Policies for Implementation of the Wet Tropics Plan.*

APPENDIX B - PROJECT 2 DESCRIPTION

Title Stream Rehabilitation Protocols and Techniques

Key researchers I. R. Kapitzke (JCU), J.C. Patterson (JCU), R.G. Pearson (JCU), A.H. Arthington (GU), B.J. Pusey (GU)

Duration **Start** 07/99 **End** 06/05

Background/ Relationship to CRC and Program goals

Many north Queensland streams, including those in the Wet Tropics region in particular, have been severely degraded by human use and development pressures, and are in urgent need of rehabilitation to maintain human utility (eg. water supply and amenity) and to preserve natural ecosystem function (eg. biological diversity and habitat conservation). The *Wet Tropics Information Needs for Management* (WTMA 2000) and the *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999) have each identified priority areas for research and development into stream rehabilitation in the region. Stream rehabilitation issues have similarly been raised in the *R and D Workshop for Water in the Wet Tropics* (conducted by Project members in Cairns in October 2000), and in the *Water Research Plan* and the *Infrastructure Audit,* presently being completed as part of Project 1.

Limitations in stream rehabilitation planning, design and implementation practices have inhibited practitioners and managers from achieving sustainable outcomes for north Queensland coastal streams from the Daintree to the Pioneer Rivers. Industry guidelines prepared by members of the project team in an earlier LWRRDC funded project (see *Stream stabilisation for rehabilitation in north-east Queensland*, Kapitzke *et al.* 1998) are now used extensively in stream rehabilitation projects in the region. Project team members are involved in implementation of these guidelines through participation in consultancies, collaborative research projects and training workshops with stream management agencies, consultants and others.

Nevertheless, much work needs to be undertaken to adequately equip stream management agencies, practitioners and managers with the planning and design tools, and the implementation techniques for multi purpose stream rehabilitation outcomes. This is confirmed through participation and consultation with stakeholders who have identified three major areas which our research should pursue:

- Stream rehabilitation planning and design protocols
- Stream processes and characteristics
- Stream rehabilitation treatments and management practices.

Stream rehabilitation planning and design protocols

Whereas conventional stream rehabilitation programs emphasise narrow objectives such as flood and erosion control, management plans and rehabilitation programs for streams in the region must incorporate multiple objectives. This involves integrated environmental management practices, which reflect the vision, goals and objectives for regional and local management plans (eg. FNQ 2010 Regional Plan; Catchment Rehabilitation Plans and Strategic Plans for various catchments). These stream rehabilitation plans must address goals for (i) ***flood and erosion control***; (ii) ***water quality***; (iii) ***habitat and conservation***; and (iv) ***amenity and cultural values***.

Project team member (RK) is presently collaborating with stream management agencies and consultants in developing management action plans for a number of streams in the region, including the Barron River, Mulgrave River, Liverpool Creek, Tully River, Gregory River. Planning and design

protocols for stream rehabilitation at the whole-of-stream and reach scale are progressively being developed through involvement in these projects. These protocols provide a basis for practitioners and managers to establish the appropriate rehabilitation treatments or management actions to address stream degradation problems at a site, as well as providing a basis for prioritisation of remediation programs at these sites. In doing so, the protocols must address multiple stream management objectives, recognise stream system behaviour and the cause of stream degradation problems, and incorporate risk evaluation into the prioritisation procedure.

For example, the *Liverpool Creek Management Action Plan*, recently prepared by the Johnstone River Catchment Management Association (JRCMA) and the Johnstone Shire River Improvement Trust (JSRIT), incorporates multiple objectives that are centred around integrating the beneficial natural and social values of the creek with flood risk management, erosion control, provision of suitable water quality, and others. Conventional objectives relating to flood and erosion control are paramount in agricultural areas such as Liverpool Creek, where farm infrastructure and crops are located in close proximity to the stream bank, and public infrastructure such as roads, rail lines, power supply and communications cross or abut the stream throughout its length.

Rehabilitation works in Liverpool Creek must comply with Commonwealth and State government provisions for funding such as NHT, and regulatory requirements such as the *Environmental Protection Policy for Water* – Environmental Protection Act 1994. The *Liverpool Creek Management Action Plan* must therefore address environmental issues relating to water quality management, minimisation of downstream impacts, and provisions for aquatic and terrestrial habitat enhancement. The Liverpool Creek catchment is partly located within the Wet Tropics World Heritage Area and is governed by provisions for natural and cultural heritage incorporated in the *Wet Tropics Plan*. In addition to this, JSRIT and JRCMA considerations for the stream must include amenity and aesthetic values, and cultural aspects relevant to traditional owners.

Furthermore, the *Mulgrave River Management Action Plan*, presently being finalised for the Cairns River Improvement Trust provides a good foundation for the proposed catchment case study (Project 6) on stream condition assessment, restoration priorities and techniques, monitoring and performance evaluation for the Mulgrave River. The Mulgrave River Action Plan extends the planning, design and evaluation methodologies for multipurpose stream rehabilitation developed in earlier projects, and provides a good case example and model for further development of a protocol to be applied throughout the region.

Stream processes and characteristics

Many stream rehabilitation activities undertaken throughout the region by stream management agencies are implemented without adequate consideration of the stream processes, and characteristics, and the causes of the remediation problems that is to be addressed. This has major negative impact on the rehabilitation programs, as the remediation measures commonly fail to address the causes of the problems and therefore cannot satisfactorily withstand the natural processes or the human pressures on the system.

This problem can occur with “hard engineering” structural treatments such as rigid or rock revetments, as well as with “soft engineering” treatments such as revegetation. The appropriate solution must take account of the stream processes and cause of the problem, and may include a mix of structural (eg. rockwork or alignment training fences) and non structural (eg. revegetation or land use changes). Some revegetation programs such as those undertaken by the Wet Tropics Tree Planting Scheme (WTTPS) teams and local catchment groups have a mixed record of success, with some plantings damaged shortly after implementation, as they are unable to withstanding the severe hydrologic and stream process loadings without structural protection.

North Queensland Afforestation Association (NQAA) has identified the need for improved understanding of stream processes and the causes of stream problems in establishing their annual program of revegetation schemes for the region. NQAA have requested assistance in a review of hydrological and geomorphological aspects of riparian revegetation schemes for the WTTP scheme. Project team member (RK) is participating in NQAA's quality assurance program to determine viabilities and priorities for revegetation projects, and it is apparent that neither the NQAA assessors nor the practitioners and managers submitting the proposed rehabilitation proposals have access to sufficient information on stream processes to adequately develop and assess the remediation schemes.

A considerable amount of information on stream hydrological and geomorphological processes that is available in the literature, is either inaccessible to the prospective users, or is not in a form that can be readily used. Some data are however available for various stream systems through strategic planning studies, flood hydrology studies, stream condition assessment reports, river management plans, rehabilitation schemes, and others. By carefully reviewing, extracting and collating these data, a summary report on stream condition assessment, stream processes and characteristics can be prepared to assist practitioners and managers in stream rehabilitation projects.

Stream rehabilitation treatments and management practices

Project team member (RK) is presently collaborating with various stream management agencies and consultants in the planning, design and implementation of multipurpose stream rehabilitation treatments and management practices for several streams in the region. This involves developing an appropriate planning and design protocol to evaluate the suitability of treatment techniques in meeting multiple objectives, and developing, monitoring and evaluating appropriate remediation techniques for the particular stream conditions.

For example the Louisa Creek project being undertaken in association with Townsville City Council is a multipurpose stream rehabilitation project, aiming to deliver improved water quality, along with flood and erosion control, improved amenity and upgraded habitat and conservation values in an urban environment. The water quality improvement program and pollution control devices are funded under NHT Coast and Clean Seas, while the hydraulic upgrade and the habitat enhancement components are contributed by the council. The challenge is to develop an appropriate stream redevelopment and rehabilitation plan to meet the multiple objectives. Habitat reinstatement and conservation is an essential part of the project, and involves designing, monitoring and evaluating appropriate habitat enhancement techniques such as pools and riffles, overhanging banks and large woody debris structures.

A rehabilitation project in the lower reaches of Sandy Creek near Mackay provides another opportunity to collaborate with stream management agencies and consultants on the planning, design and implementation of a multipurpose stream rehabilitation project in an urban environment. As is common in these settings, agricultural land adjoining the river is lost to a migrating river bank, the valuable riparian corridor is destroyed, in-stream habitats are damaged due to inappropriate remediation methods such as placing car bodies, and the river threatens to avulse through a new course to the mouth, isolating existing communities and infrastructure on the river. Innovative alignment training works using timber pile groynes are proposed for the site and the project team will be involved in developing designs, monitoring and evaluation, and undertaking training workshops for practitioners and managers to demonstrate stream rehabilitation planning and design approaches and remediation techniques.

Furthermore, the catchment case study (Project 6) on the Mulgrave River provides an opportunity to develop and trial best practice stream rehabilitation techniques for the Wet Tropics region. It is intended that this project will include a component of planning, design and implementation, monitoring and performance evaluation of particular remediation projects, which, along with the Louisa Creek and Sandy Creek projects will provide a basis for improved practices in the region.

Potential applications of the research

The major applications of this R and D will come through the development of planning and design protocols for multi purpose stream rehabilitation, basic information on stream process and characterisation data through the region, and improved knowledge of suitable remediation techniques for stream rehabilitation in urban and rural environments. This will provide better outcomes for stream management agencies and consultants undertaking stream rehabilitation projects, and will benefit practitioners and managers involved in the planning, design and implementation of remediation programs.

Objectives

The objectives of this sub-project are to:
- develop planning and design procedures for multi purpose stream rehabilitation at various scales ranging from whole-of-stream, to reach and site scales
- provide a better understanding of stream processes for the region
- document stream behaviour and characterisation data for use by stream management agencies and consultants in stream remediation programs
- review, develop, monitor and evaluate improved stream rehabilitation techniques and management practices for significant urban and rural environments
- develop and test the stream rehabilitation protocols and techniques on the Mulgrave River case study project.

Outputs

The outputs of this sub-project will be:
- Planning and design protocols for multi purpose stream rehabilitation at reach and site scales
- An annotated bibliography of stream process and condition data for North-east Queensland coastal streams
- Evaluation of the effectiveness of various stream rehabilitation techniques in urban and rural environments
- Demonstration sites on various streams (eg. Mulgrave River) for improved stream rehabilitation practices.

Linkages/ Collaborators

Other project type	Nature of linkage
Within CRC	Links with Program 5 on riparian rehabilitation techniques
Other	Preparation of stream rehabilitation management action plans for various river systems with agencies and consultants
	Developing and trialing improved remediation techniques in collaboration with stream management agencies
	Conducting stream rehabilitation training workshops for practitioners and managers

Who are the key stakeholders?

The following stakeholders are involved in the research project through participation in workshops, consultations and other collaborative activities:
- Wet Tropics Management Authority
- Environmental Protection Agency
- Department of Natural Resources (now DNR&M)
- Department of Local Government and Planning
- Department of Primary Industries
- Local Authorities
- North Queensland Afforestation Association

- Catchment Coordinating Committees
- River Improvement Trusts
- Consultants (eg Natural Resource Assessments).

Research strategy and proposed methods

This project will involve extensive case study analysis and collaboration with practitioners and managers involved in stream rehabilitation planning, design and implementation in streams throughout the region. It will be undertaken in association with the Mulgrave River case study (Project 6), which aims to develop a set of "Best Practice" guidelines, protocols, manuals etc. for use in the Wet Tropics Bioregion. The intention of the case study is to assess stream bank, riparian and in-stream condition, decide on priorities and techniques for restoration and other on-ground works, and to test outcomes of selected works via research and monitoring, leading to development and collation of the guidelines. The priorities and methods for rehabilitation of degraded riparian zones on the Mulgrave River and other river systems will be linked to research outcomes in this project.

The planning and design studies, and the Mulgrave River case study project in particular, will provide an opportunity to develop improved stream rehabilitation protocols; to understand and document stream process and characterisation data for the region; and to implement, monitor and evaluate rehabilitation techniques at selected sites to address bank erosion, degraded riparian habitat, altered flow regime etc.

The elements that will be involved in this sub-project include planning and design procedures (eg. spatial and temporal hierarchy), planning and design tools (eg. site prioritisation, evaluation of alternatives), development and rehabilitation techniques (eg. alignment training, bank stabilisation), understanding of natural ecosystem processes and interaction with human use (eg. stream hydrology, disturbance ecology, impacts on aquatic biota), having guiding principles (project phasing, multiple objectives, interdisciplinary approach) and linkages between project participants and other stakeholders (consultation, extension).

Stream rehabilitation planning and design protocols

By undertaking cases studies, and through collaboration with stream management agencies and design practitioners, this project develops planning and design procedures, tools and techniques for stream rehabilitation projects, which meet multipurpose requirements for human use (eg. flood and erosion control, water quality, recreation and amenity) and natural ecosystem function (eg. biodiversity, conservation).

Participation in several consultancies and collaborative research projects for stream rehabilitation planning, design and implementation has demonstrated the need to improve existing rehabilitation protocols in the following manner:

Differentiate between ***study management stages*** (eg. stakeholder consultations, site inspections, and other project team and system assessment logistics) and ***planning and design steps*** which run in parallel with the study tasks (eg. identification of problems, evaluation of options, prioritisation).

Provide more extensive ***analysis of stream behaviour and human impacts*** in determining the causes of stream management problems, and in assessing the suitability of various rehabilitation options in meeting stream management objectives.

Improve the ***transparency*** and ***objectivity*** in developing ratings, weightings, risk levels, costs and benefits related to the significance of stream problems and issues; the suitability and success of rehabilitation options; and the prioritisation of stream management actions.

Stream processes and characteristics

The project will collate existing stream process and characterisation data for the region and produce an inventory of relevant information for use by practitioners and managers in stream rehabilitation planning, design and implementation. This literature will provide basic data on stream processes (hydrology, geomorphology etc.), infrastructure development and rehabilitation measures for catchments in the region. It will assist NQAA and others to determine appropriate areas and techniques for structural (eg. revetment and alignment training) and non-structural (eg. revegetation and land use change) remediation measures.

Stream rehabilitation treatments and management practices

Case study analysis and trial application of various rehabilitation techniques will be undertaken in urban and rural stream environments (eg. Louisa Creek, Sandy Creek, Mulgrave River) to develop rehabilitation techniques to improve the physical and biological condition of urban and rural stream environments, degraded through channelisation, encroachment etc. This will include studies into the effectiveness of habitat restoration (eg. pools and riffles, large woody debris) for aquatic invertebrates and fish, and the suitability of stream alignment techniques (eg. timber pile groynes and retards) for stabilisation and riparian rehabilitation.

Monitoring and evaluation programs will be developed in collaboration with stream management agencies, and training workshops will be undertaken to assist practitioners and managers with improved practices.

Work Plan

	99/00				00/01				01/02				02/03			
Task	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Collate information on stream rehabilitation problems & practices		XX	XX	XX	XX	XX	XX	XX								
Collaborative research and consultancies			XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Develop planning and design protocols					XX	XX	XX	XX	XX	XX	XX	XX				
Compile stream process and characterisation data		XX	XX	XX	XX	XX	XX	XX	XX	XX						
Develop, implement and test rehabilitation practices											XX	XX	XX	XX	XX	XX
Mulgrave River case studies									XX	XX	XX	XX	XX	XX	XX	XX
Training workshops										XX				XX		

Milestones

Milestones	*Due date for Completion*
Collaboration with agencies and consultants	ongoing
Development of planning and design protocols	06/02
Stream process and characterisation report	12/01
Develop and test rehabilitation practices	06/03
Commence Mulgrave River case studies	06/01
Conduct training workshops for practitioners and managers	12/01, 12/02

Communication plan

Extensive communication with stream management agencies, consultants and other stakeholders will be achieved through participation in the collaborative research activities, including data compilation, development of stream rehabilitation plans, and through case study projects such as the Mulgrave River. Practitioners and managers will be closely involved in consultancies, case study analyses and the training workshops. Results will be published for wide distribution and use.

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Wet Tropics Management Authority 1997 *Protection Through Partnerships: Policies for Implementation of the Wet Tropics Plan.*

APPENDIX C - PROJECT 3 DESCRIPTION

Title Road drainage, waterways and fauna crossings

Key researchers I. R. Kapitzke (JCU), J.C. Patterson (JCU), R.G. Pearson (JCU)

Duration **Start** 07/99 **End** 06/05

Background/ Relationship to CRC and Program goals

Linear infrastructure such as roads have a potentially major impact on tropical rainforest and stream environments in the Wet Tropics as a result of severence of habitat continuity, disturbance to the stream corridor, blockage to terrestrial fauna and fish passage, sedimentation and water pollution. Whereas conventional practices for road developments in these environments have focused on transport and drainage functions, modern road projects must incorporate environmental provisions relating to water quality, biodiversity and habitat conservation, as well preserving amenity and cultural values.

The *Far North Queensland Regional Plan* (Far North Queensland Regional Planing Advisory Committee 1999) identifies priorities to avoid or mitigate the environmental impacts of transport services on the region's natural areas and environmental values. The Regional Plan emphasises management and protection of World Heritage values, natural areas, scenic amenity and natural processes, and seeks compliance with the requirements of the Environmental Protection Act 1994, and incorporation of environmental values into the planning, design, construction and maintenance of transport infrastructure in the region.

The Wet Tropics Management Authority, through their Rand D plan, *Wet Tropics Information Needs for Management* (WTMA 2000), have also identified a lack of understanding of fundamental principles relating to landscape, ecology and amenity values, in the design, construction and maintenance of linear corridors such as roads. WTMA's goals for road management and maintenance is to see the development, implementation and testing of 'best practice' approaches relating to traffic, barrier and other effects.

Industry stakeholders, including WTMA and Main Roads Department (MRD), have developed and adopted environmental guidelines for the planning, design and management of transport infrastructure in the region, including *Roads in the Wet Tropics* and codes of practice relating to road operations and maintenance. Nevertheless, many gaps remain in the capacity for practitioners and managers to achieve sustainability in road infrastructure developments. The *Water Research Plan*, prepared following the R and D workshop conducted by Project 1.3 (now 4.4) in Cairns in October 2000, and the *Infrastructure Audit*, presently being completed as part of Sub-project 1, have each identified shortcomings to be addressed in research and development into road infrastructure planning and design in the region.

Planning and design protocols for major projects, as reflected in MRD design manuals, incorporate environmental goals early in the planning phases, but these environmental values are not always effectively incorporated into the subsequent design steps, or reflected in the project outcomes. Local authorities (eg. shire councils) are generally not so progressive in environmental practices for road planning and design, and the need for codes of practice for local authorities has been identified. Local authorities such as Douglas Shire Council have expressed a desire for guidance on the development of improved practices for road infrastructure design, particularly related to waterway crossings.

Several major regional road projects have made innovative attempts at providing for habitat and conservation: Kuranda Range Road, Evelyn Tablelands Highway, Mission Beach Road.

Rainforest CRC Program 4 researchers (Leader: Steve Turton) are involved in collaborative research activities with MRD, WTMA and others on the effects of road corridors and transport on habitat segregation, fauna crossings, sedimentation, pollution and other impacts. It is now important to supplement the ecological aspects of the Program 4 research with engineering considerations, which can help develop techniques for fauna underpasses, overpasses etc, and incorporate these measures into designs for new or retrofitted road projects.

To help equip road agencies, local authorities, practitioners and managers with the planning and design tools, and the implementation techniques for sustainable road infrastructure projects, we have identified five major areas which our research should pursue:

- Remediation of fish migration barriers at road culverts
- Road infrastructure designs to fauna crossings
- Effects of road crossings on the stream corridor
- Effective sediment basins
- Pollution control devices.

Remediation of fish migration barriers at road culverts

Obstacles to fish movement at stream crossings such as road culverts can severely deplete fish populations and reduce the diversity of fish species within a catchment by limiting their reproductive capability. High velocities, excessive exit drops, or flow turbulence in many new or existing road culverts represent a barrier to fish migration to critical spawning or growth habitats, often causing impacts as severe as those resulting from larger structures such as dams and weirs.

Various remediation techniques can be adopted to create appropriate flow conditions for fish passage in order to overcome fish migration barriers at existing culverts or to mitigate the effects at new culverts. Many of the available techniques relate to other regions in Australia and overseas, however, and practices for remediation of barriers affecting streams and fish species of the Wet Tropics are not well developed. Information on the migration characteristics, swimming capabilities and other lifestyle requirements of many northern, native freshwater fish species is lacking, and the limiting design specifications such as stream flow range and velocities on which to base culvert design are not adequately specified.

Although the types and causes of culvert barriers are generally well understood, comprehensive planning and design guides for remediation measures are not yet available for the Wet Tropics region. For example, only rudimentary provisions for fish passage design are made in the new *MRD Road Drainage Design Manual*. Very few examples exist in north Queensland streams where provision has been made for fish passage. Although not yet implemented, innovative designs have recently been considered for new and retrofitted culverts in the Tully-Murray Sugar Infrastructure project.

A project presently underway in CRC Project 1.3 (now 4.4) is developing remedial fishways for a stream on the James Cook University Townsville campus, where several road culverts are restricting fish migration to important habitats. The fishway proposals have been taken to concept level design in preparation for laboratory model tests and development of prototype fishways for these culverts. The intention is to install and monitor performance of these remediation measures, and to examine their application to other streams in the region.

Road infrastructure designs for fauna crossings

Transport corridor infrastructure can have a major impact on native fauna through road mortalities and reduction in breeding opportunities, resulting from destruction and fragmentation of available habitat for many species (MRD 2000). Road designers are now endeavouring to make better provision for movement of fauna through the road corridor, particularly for icon species such as the cassowary, tree kangaroo, and several arboreal mammals. Rainforest CRC researchers from Program 4 are

collaborating with MRD designers to install and monitor overpasses (eg. canopy bridges), level crossings (eg. traffic-calming devices) and underpasses (eg. culverts) for these and other fauna.

Designers require more information and specific guidelines to determine the need for, the location, the type and the layout, configuration and sizing of these fauna crossing measures. For example, the significance of the habitat corridor for arboreal mammals at a particular location will govern the need for a placement of a canopy bridge. Wildlife fences and traffic-calming devices should be carefully configured to suit animal behaviour for cassowary crossings. Culvert or bridge underpasses at waterways should provide for both instream and terrestrial fauna passage. As well as providing for fish passage within the stream channel (refer above), stream crossings could incorporate raised benches and openings of an adequate height for mammal passage on the edge of the stream.

Effects of road crossings on the stream corridor

Apart from presenting a barrier to the passage of in-stream and terrestrial fauna, road crossings also commonly have other major effects on the stream corridor. Designers normally provide for control of erosion and other damage at bridges, culverts and causeways by limiting flow velocities and turbulence, and by minimising disturbance to the stream channel. Nevertheless, terrestrial and instream habitat destruction, infestation with exotic weeds, downstream sedimentation and degraded amenity may result from vegetation clearing, encroachment of approach embankments and drainage structures on the waterway, channelisation and lining of the stream channel, or other modifications.

New road drainage design procedures (eg. MRD 2000) attempt to provide for integrated planning and design for road drainage and waterway crossings to achieve multiple objectives related to transport, hydraulics, ecology etc. The goal for sustainability for these road-waterway crossings is often inhibited by poor design and construction practices, and a lack of planning and design procedures, tools and techniques to rehabilitate degraded sites, and to mitigate adverse effects on the streams. Apart from soft engineering and non-structural measures such as preservation of riparian corridors, revegetation, weed management etc, structural measures such as alignment training works, bed chute control structures and habitat restoration measures may also be required.

Effective sediment basins

Soil erosion from exposed sites and sedimentation of downstream waterways are major issues for Wet Tropics areas subject to severe rainfall events. The problems are particularly severe for roadworks, where extensive sections of the road corridor are exposed to rainfall and erosion during and immediately after construction. Although erosion control measures are now employed extensively in road cuttings, table drainage and cross drains, large quantities of sediment are still being delivered to receiving waters, blocking stream channels and causing habitat degradation.

Sediment basins are conventionally used in urban and rural drainage schemes to collect eroded materials before delivery to receiving waters. Sediment basins function by temporarily retaining runoff water and slowing flow velocities, and they require relatively large areas on a site with suitable topography. Although sediment basins would be beneficial in road drainage projects, they are not readily suitable as limited land is generally available within the road corridor. Research is therefore needed into the appropriate location and configuration for sediment basins for road projects, the runoff hydrology, and the sedimentological and hydraulic characteristics of the collection pond.

Pollution control devices

Pollutants generated from vehicle traffic may affect significant stream and wetland ecosystems if they are delivered in critical concentrations to receiving waters that are in a sensitive ecological condition. Pollutants such as heavy metals and hydrocarbons washed from the road pavement, may be transported via the road drainage systems and discharged direct to the waterways at road bridges, for

example. Concentrations of these pollutants are most severe in heavily trafficked areas, subject to extensive braking and acceleration, and are therefore most critical where road intersections are in close proximity to bridges.

Designers presently make little provision for control of pollution from road runoff in the Wet Tropics. Those waterway types, ecosystem characteristics, and ecological conditions that may be critically affected by pollution are not established. The volumes and concentrations of heavy metals, hydrocarbons and other pollutants running off paved road surfaces and table drainage into streams at bridges and other road crossings are unknown. Collection and treatment systems for pollutant runoff are not yet adequately developed.

Potential applications of the research

The major applications of this R and D will come through the development of planning and design protocols, tools and techniques for road drainage, waterway crossings, fauna and fish passage. This will provide better outcomes for road management agencies, local authorities and consultants involved in road projects, and will benefit practitioners and managers involved in road planning, design, implementation and maintenance.

Improved practices will be developed through collaboration with Main Roads Department, local authorities, WTMA and others. This will progressively lead to road, culvert and waterway crossing designs that cater for fish passage, provide for fauna crossings, reduce impacts on the stream corridor, and minimise the effects of sediment and pollution from road runoff.

Objectives

The objectives of the sub-project are to:
- understand stream flow and fish migration characteristics for streams in the region
- develop and test various techniques for remediation of fish migration barriers at road culverts, using field measurements, laboratory models and prototype installations
- develop planning and design procedures, tools and techniques for remediation of fish migration barriers at road culverts
- examine the effectiveness and feasibility of various techniques for provision for road fauna crossings
- develop planning and design procedures, tools and techniques for road fauna crossings
- examine the significant effects of road crossings on the stream corridor, and identify measures to minimise these effects
- examine alternative means for provision of effective sediment basins, and develop appropriate planning and design guides for these sediment control measures
- examine the significance of pollutant runoff into critical waterways at road bridges, and identify measures to minimise these effects.

Outputs

The outputs of this sub-project will be:
- Prototype installations for remediation of fish migration barriers at road culverts
- Planning and design procedures, tools and techniques for remediation of fish migration barriers
- Planning and design procedures, tools and techniques for road fauna crossings
- Evaluation of the effects of road crossings on the stream corridor, and identification of measures to minimise these effects
- Identification and evaluation of measures for effective sediment control for roads
- Evaluation of the effects of pollutant runoff at road bridges, and identification of measures to minimise these effects.

Linkages/ Collaborators

Other project type	Nature of linkage
Within CRC	Links with Program 4 on impacts of roads and alternative mitigation measures
Other	Collaborative research with agencies and consultants on measures to remediate fish migration barriers
	Developing and trialing measures for road fauna crossings in collaboration with agencies
	Collaborative research with agencies and consultants on effective sediment basin design
	Developing and trialing measures for pollution control devices for road runoff at bridges in collaboration with agencies
	Conducting training workshops for practitioners and managers

Who are the key stakeholders?

The following stakeholders are involved in the research project through participation in field trials, consultations and other collaborative activities:

- Main Roads Department
- Wet Tropics Management Authority
- Queensland National Parks and Wildlife Service
- Department of Natural Resources (now DNRM)
- Department of Primary Industries - Fisheries
- Environmental Protection Agency
- Catchment Coordinating Committees
- Regional Organisation of Councils
- Local Authorities
- Consultants.

Research strategy and proposed methods

This project will involve a combination of field and office studies, and extensive case study analysis and collaboration with practitioners and managers involved in road drainage, waterways and fauna crossings throughout the region. Laboratory modelling and prototype installations will be used in the development of remediation techniques for fish migration barriers at road culverts. The work will be undertaken in association with the Mulgrave River case study (Sub-project 6), which aims to develop a set of “Best Practice” guidelines, protocols, manuals etc for use in the Wet Tropics Bioregion. The intention of the case study is to assess catchment and stream characteristics, to consider remediation and mitigation activities related to sustainable management of the system, and to test outcomes of selected works via research and monitoring, leading to development and collation of the guidelines. Prospective measures relating to road drainage, waterways and fauna crossings for the Mulgrave River and other river systems will be linked to research outcomes in this project.

The planning and design studies will provide an opportunity to develop measures for the remediation of fish migration barriers at road culverts; to improve practices for road infrastructure design for fauna crossings; to establish the effects of road crossings on the stream corridor; to examine measures for effective sediment control for roads; and to evaluate measures for pollutant runoff at bridges. Guideline documents will be developed to assist practitioners and managers involved in infrastructure development, and training workshops will be conducted, initially for culvert fishways.

Remediation of fish migration barriers at road culverts

The problem to be addressed for fish migration barriers relates to the habitat and conservation value of the stream, the hydraulic characteristics of the barrier, and the swimming capabilities of the particular fish species. The significance of the barriers depends on many parameters, including the fish

species and stream flow characteristics the fish can negotiate.
Protocols for remediation must establish the significance of the site prior to developing remediation measures. It is vital to know: which streams are important (eg. perennial, intermittent), the most significant sections of the streams (eg. lowlands, uplands), and the critical fish species and their migration characteristics relative to flow (timing, extent and capability of movement). Procedures for determining the significance of the site will be developed by consultation with experts within and outside the project team, by adaptation of existing stream habitat assessments (eg. Russell and Hales), through a review of the literature relating to fish species in the Wet Tropics region, and by undertaking case studies for particular streams.

The nature of the problems to be addressed at the road crossings will be established through a survey of the type and characteristics of culverts and other structures causing barriers to fish passage throughout the region. A review of the literature will be undertaken to establish the alternative techniques that may be applied to remediation of fish migration barriers in north Queensland streams. Field and office studies will be undertaken to determine the hydraulic characteristics of the barriers and to examine remediation measures. Good field data on the patterns of movements of fish and their performance in negotiating culverts in these regions is also desirable.

Case studies on University Creek culverts on the James Cook University Townsville campus will continue, in order to establish design parameters and limiting culvert specifications such as water velocities, and the location and interval between resting areas. Field monitoring will include flow measurements, fish surveys, swim characteristics, and fish movement observations. New *Acoustic Tag Tracking* equipment recently acquired by Arthington and Pearson (ARC REIF 2000) will be trialed for fish movement studies. Hydraulic laboratory modelling will be undertaken to examine the flow characteristics of various fishway components, and these will be trialed in prototype fishways to be installed in the culverts. These studies will help determine the suitability of the fish remediation techniques for use on other streams in north Queensland.

Road infrastructure designs for fauna crossings

The goals of this sub-project are to examine road underpasses (eg. culverts), overpasses (eg. canopy bridges), and associated facilities that are effective as road crossings for terrestrial fauna in sensitive rainforest environments, and to produce guidelines on suitable road infrastructure designs for fauna crossings. The studies will be undertaken in close collaboration with Program 4 researchers (Turton *et al*), road agencies and consultants.

The intention is to develop design criteria for use by practitioners and managers in the planning and design of fauna crossing measures for new or retrofitted road projects. Engineering considerations will be developed to supplement ecological aspects involved in determining the need for, the location, the type, and the layout, configuration and sizing of fauna crossing measures. Case study projects such as the Kuranda Range Road, Evelyn Tablelands Highway, Mission Beach Road will be used to examine overpasses (eg. canopy bridges), level crossings (eg. traffic calming) and underpasses for instream and terrestrial fauna passage (eg. culverts).

Effects of road crossings on the stream corridor

A classification system for streams and road crossings will be developed, and an inventory will be prepared describing stream sites in the region severely affected by road crossings. Stream crossings within and adjacent to the WHA are important as each may affect habitat corridor connection or stream ecosystem health within the WHA. The relative significance of various impacts on the streams will be examined (eg. terrestrial and instream habitat destruction, infestation with exotic weeds, downstream sedimentation and degraded amenity). The likely causes of these problems (eg. clearing, encroachment, channel modifications) will be established and potential remediation or mitigation measures will be developed. Case studies will be used and close collaboration will be maintained with road and environmental agencies and consultants.

Effective sediment basins

The initial work on this sub-project will review the type of sediment control measures used in road projects, and will examine the potential for use of sediment control basins in the construction and operation phases. Full retention of sediments is unlikely to be achievable due to the limited land that is generally available within the road corridor. Case study analyses will be used to examine appropriate location and configuration for sediment basins, site constraints and limitations, runoff hydrology, and the sedimentological and hydraulic characteristics of the collection pond. Close collaboration will be maintained with road and environmental agencies and consultants.

Pollution control devices

The classification of stream types and road crossings (see above) will be used in this sub-project to examine the relative significance of the pollution problems generated from vehicle traffic and delivered into significant stream and wetland ecosystems. The waterway types, ecosystem characteristics, and ecological conditions that may be critically affected by pollution will be identified. Field experiments will be set up to measure volumes and concentrations of heavy metals, hydro carbons and other pollutants running off paved road surfaces and table drainage into streams at bridges and other road crossings. Options for collection and treatment of pollutant runoff will be examined using case study analyses. Close collaboration will be maintained with road and environmental agencies and consultants, and with CRC researchers in Sub-project 4, who are examining the effects of stream crossings on stream water quality and aquatic wildlife.

Work Plan

	99/00		00/01						01/02				02/03			
Task	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Examine stream flow and fish migration characteristics for streams in the region			XX	XX	XX	XX	XX	XX	XX	XX	XX	XX				
University Creek culvert fishway field studies and laboratory modelling			XX	XX	XX	XX	XX	XX	XX	XX						
University Creek culvert fishway prototype installation and testing										XX	XX	XX	XX	XX	XX	XX
Develop planning and design procedures for culvert fishways													XX	XX	XX	XX
Examine road fauna crossings									XX	XX	XX	XX	XX	XX		
Develop planning and design procedures for road fauna crossings															XX	XX
Examine mitigation measures for the effects of road crossings on the stream corridor											XX	XX	XX	XX	XX	XX
Examine measures for effective road sediment basins															XX	XX
Examine measures to mitigate the effects of pollutant runoff at road bridges								XX	XX	XX	XX	XX	XX	XX	XX	XX
Training workshops																XX

Milestones

Milestone	*Due date for completion*
University Creek culvert fishway laboratory model report	12/01
Install University Creek culvert fishway prototype	12/01
Develop planning and design procedures for fishways	06/03
Complete first stage case studies on road fauna crossings	12/02
Develop first stage planning and design procedures for road fauna crossings	06/03
Complete initial studies on road sediment basins	06/03
Complete first stage studies on pollution control devices at bridges	06/03
Conduct training workshops for practitioners and managers - culvert fishways	06/03

Communication plan

Extensive communication with management agencies, consultants and other stakeholders will be achieved through participation in the collaborative research activities, including data compilation, field studies, development of prototype culvert fishways, and through case study projects. Practitioners and managers will be closely involved in field studies, case study analyses and the training workshops. Results will be published for wide distribution and use.

Key references

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Parker, M 1999, *A Discussion of Fish Passage at Culverts in the Cariboo Region, British Columbia*, B.C's Watershed Restoration Technical Bulletin, p 9-14.

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APPENDIX D - PROJECT 4 DESCRIPTION

Title Environmental Quality and Ecological Sustainability

Key researchers Richard Pearson (JCU), Niall Connolly (JCU), Michael Crossland (JCU), Barry Butler (JCU), Alastair Birtles (JCU), Angela Arthington (GU), Brad Pusey (GU)

Duration **Start** 07/99 **End** 06/05

Background/relationship to CRC and Program goals

Excellent water quality and high levels of biodiversity are the hallmarks of the Wet Tropics. Indeed, previous Rainforest CRC research suggests that both criteria reach their global peaks in the Wet Tropics. Sustaining the peaks in a major challenge given the demands on land and water for human purposes. Therefore, one of the crucial problems facing land managers in the Wet Tropics is the relationship between (i) use of the land and water, (ii) its impact on habitat and water quality, and (iii) the attendant effects on the aquatic biota. The issue is important not only because it is vital to manage environmental quality to sustain current high levels of water quality and biodiversity in streams, but also because it is necessary to maintain a healthy human environment, especially where water is used for human purposes, including domestic supply and recreation. This project examines the interactions between species, communities and environmental quality and has a double purpose. Firstly, it allows determination of the environmental requirements of a healthy biota; and secondly it provides for calibration of the biota as an environmental monitoring system.

Recognition that successful management of waterways and water quality is a key issue in the Wet Tropics, is explicit or implicit in various exercises in identification of strategic approaches to management (eg. the Wet Tropics Plan; the FNQ 2010 Regional Plan; the Rainforest CRC proposal document; the recent CRC Water Workshop). Previous work in the CRC has focussed on inventory and ecological processes; this project will complete this work by presenting it in an applied context, and will undertake new research to address explicit applied problems. The project includes tasks that are partly or wholly funded from external sources, and tasks funded completely by the CRC.

The project aims to quantify the effects of various impacts on water quality and on the instream biota, and thereby develop guidelines for on-going management. It addresses these issues through a series of related tasks:

Task (i) Infrastructure: ***Road drainage, road crossings, water quality and stream biotas*** **–** Richard Pearson and Niall Connolly, JCU; Angela Arthington and Brad Pusey, GU

A major issue for managers is the impact of stream crossings on water quality and aquatic wildlife. This project will select a number of crossing types (eg. courseways, culverts and bridges, and sealed and unsealed roads, each with examples of different levels of usage) and analyse water quality and sediments upstream and downstream before, during and after rain events. It will investigate the biota (invertebrates and fishes) at upstream and downstream sites. The outcomes will be a classification of crossing types on the basis of levels of impact, and guidelines to best practice design of stream crossings. This project links closely with Sub-project 3.

Task (ii) Agriculture: ***Quantifying the effects of cane field drainage on water quality and aquatic fauna*** **-** Richard Pearson and Michael Crossland, JCU**.**

This project is funded by SRDC and includes experimental studies that complement CRC-funded research. It is involving field surveys of water quality and faunal distributions in relation to drainage

from sugar cane fields, and experimental studies on the tolerance of freshwater animals (invertebrates and fishes) to selected contaminants. The outcomes will include an understanding of the quantitative impact of the sugar industry on lowland tropical streams and guidelines for reducing impacts through improved management.

Task (iii) Recreation and tourism: ***Guidelines for best practice stream-based recreation in the Wet Tropics*** **–** Barry Butler, Alastair Birtles and Richard Pearson, JCU

This project is due for completion in 2001. It has been funded under the Federal ecotourism initiative, and by the CRC. It has examined the effects on water quality of recreational use of streams in the Wet Tropics, and is currently developing models of water quality behaviour for application in improved management. It is also producing a series of publications for managers and the tourism industry on the attractions, ecologically sound utilisation and best practice management of Wet Tropics streams.

Task (iv) Rapid Assessment: ***Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams*** **–** Richard Pearson, Niall Connolly and Michael Crossland, JCU

This publication is the culmination of a long-term project examining the invertebrate communities of Wet Tropics streams. It will provide a toolbox for managers (including consultants) for monitoring water quality and habitat integrity using stream invertebrates as indicators of disturbance.

Task (v) Flows: ***Invertebrate/flow relations in Wet Tropics streams*** – Richard Pearson and Niall Connolly, JCU; Angela Arthington and Brad Pusey, GU

There is now a substantial body of research that addresses environmental flow requirements in relation to habitats and fish communities in the Wet Tropics. However, the issue of flow needs for invertebrate communities has not been directly addressed. While previous work clearly indicates that flow regime dictates habitat which in turn acts as a template that determines the invertebrate community, it is not clear to what extent flow regimes must be varied to cause changes in the template and the community. This is an important issue because invertebrate communities represent a large proportion of the biodiversity in streams, they are vital links in food webs, and they are the predominant or even the only fauna living in the thousands of kilometres of small upland streams.

This sub-project addresses this issue by experimentally manipulating flows under a series of different regimes, ranging from natural through various artificial scenarios (based on real situations). It will test hypotheses derived from parallel studies focussing on fish and fish habitats and thereby aim to develop an integrated view of environmental flow requirements and management guidelines for Wet Tropics streams from source to mouth. The methodology will involve flow manipulations *in situ* using our current standardised benthic sampling protocols, and artificial stream channels, as appropriate.

Potential applications of the research

All the tasks are explicitly designed to address management problems, with direct application of results an integral part of each task, as follows:

Task	Application
(i) *Road drainage, road crossings, water quality and stream biotas*	The task will classify road crossing types with regard to nature of the road, design of the crossing, and levels of impact, and will produce guidelines to best practice design of stream crossings for use by relevant agencies.
(ii) *Quantifying the effects of cane field drainage on water quality and aquatic fauna*	Quantification of impacts will lead to guidelines for mitigation through improved land and water management.
(iii) *Guidelines for best practice stream-based recreation in the Wet Tropics*	The current phase of the task involves development of practical models of water quality behaviour for application in improved management; it is also producing a series of publications for managers and the tourism industry on the attractions, ecologically sound utilisation and best practice management of Wet Tropics streams.
(iv) *Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams*	This task will provide a toolbox for monitoring water quality and habitat integrity using stream invertebrates as indicators of disturbance, to be used in site assessments, sates of the environment reporting, etc.

Objectives

The objectives of this project are to provide a sound scientific basis for stream management, and to develop the research into a series of practical outputs and outcomes, as follows:

Task	Objectives
(i) *Road drainage, road crossings, water quality and stream biotas*	Classify stream crossings according to road/rail type. Assess water quality and sediments upstream and downstream before, during and after rain events. Describe the biota (plants, invertebrates and fishes) at upstream and downstream sites. Develop a cause/effect model linking crossing type to impact. Perform targeted experiments to test the model and demonstrate impacts. Produce guidelines to best practice design of stream crossings.
(ii) *Quantifying the effects of cane field drainage on water quality and aquatic fauna*	Describe water quality of cane-field drainage and receiving waters. Identify key contaminants and processes. Investigate tolerance of key species or communities to selected contaminants. Develop models linking agricultural practice, water quality and stream biota. Develop best-practice guidelines for management to reduce impacts.

(iii) *Guidelines for best practice stream-based recreation in the Wet Tropics*	Describe effects of stream-based recreation on water quality in the field. Experimentally investigate levels of input of contaminants by humans. Develop models of recreation impacts on water quality. Develop best-practice guidelines for managing water-based recreation. Develop educational material for stream users and tourism operators regarding stream values and their maintenance.
(iv) *Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams*	Describe invertebrate communities of pristine streams. Describe associations between invertebrates and key impacts. Develop protocols for assessment of habitat and water quality using invertebrates as indicators. Produce guidelines for monitoring Wet Tropics streams

Outputs

The project aims for several different levels of output for each task – namely scientific papers, CRC information sheets and issue papers, technical publications (guidelines and the like for managers) and popular brochures for occasional users. Expected outputs are

Task	Proposed outputs
(i) *Road drainage, road crossings, water quality and stream biotas*	Paper describing effects of different crossing types on water quality and biota.Paper describing effects of sedimentation on biota. Technical report outlining guidelines for best practice design of stream crossings.Information sheet on crossings and stream ecology.
(ii) *Quantifying the effects of cane field drainage on water quality and aquatic fauna*	Paper on impacts of cane field drainage on water quality in Wet Tropics streams.Paper on effects of nutrient enhancement in streams. Paper on tolerance of stream invertebrates to low dissolved oxygen (DO). Paper on tolerance of selected stream fishes to low DO. Thesis on long-term sub-lethal effects of low DO, Technical report – model of interaction between agriculture, water quality and stream biota. Technical report – guidelines for improved farm management towards improved stream quality. Information sheet – agriculture, water quality and biodiversity.
(iii) *Guidelines for best practice stream-based recreation in the Wet Tropics*	Technical report on recreation and water quality in streams. Thesis on management perspective of water quality issues. Thesis on tourist/wildlife interactions. Technical report on experimental quantification of human-borne contaminants and models of recreation/water quality relationships. Technical report: best-practice guidelines for managing water-based recreation
(iv) *Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams*	Brochure – streams and wildlife. Brochure – best practice recreational use of streams. Technical report: outcomes of technical workshops. Technical report: outcomes of stakeholder workshop. Paper on stream-base tourism/recreation: impacts, perceptions and management.
(v) Invertebrates and flow	Paper on water quality in Wet Tropics streams. Paper on invertebrate assemblages in WT streams. Technical report: invertebrates of WT streams.

Linkages/collaborators

Project	Nature of linkage
Task (i)	Direct link to Sub-project 3; sharing of sites, personnel etc.
Task (ii)	Funded by SRDC through Australian Centre for Tropical Freshwater Research Staff shared
Task (iii)	Funded by Department of Tourism and Rainforest CRC Links to other CRC projects on tourism impacts.
Task (iv)	Links to Sub-project 5, with shared staff
Task (v)	Links to other Sub-projects

Key stakeholders

The following stakeholders are involved in the research project through funding, receiving advice, participation in project workshops, consultations, etc.; and/or as recipients of outputs:

Stakeholder	Main interest area					Major beneficiary of research?
	Task (i)	Task (ii)	Task (iii)	Task (iv)	Task (v)	
Department of Natural Resources and Mining	✓	✓	✓	✓	✓	✓
Wet Tropics Management Authority	✓	✓	✓	✓	✓	✓
Environmental Protection Agency	✓	✓	✓	✓	✓	✓
Catchment Coordinating Committees				✓	✓	
River Improvement Trusts				✓		
Waterwatch		✓		✓		
Tourism operators			✓			✓
Department of Tourism			✓			✓
Environmental/Engineering consultants	✓	✓	✓	✓		✓
Land and Water Australia		✓		✓		✓
Sugar Research and Development Corp		✓		✓		✓
Canegrowers		✓		✓		✓

Research strategy and proposed methods

Tasks (i) and (v) are proposed for the first time, and are described below.

Task (ii) ***Quantifying the effects of cane field drainage on water quality and aquatic fauna*** is in progress, and is fully funded by SRDC, so no further proposal is presented here. The project is using field and laboratory experiments to understand the resistance and/or resilience of the native stream fauna to agricultural disturbance in lowland streams in the Wet Tropics. The project has direct bearing on the interests of the Rainforest CRC as the fauna and streams involved are derived from the rainforest, and the streams form a natural conduit for fauna in and out of the contiguous forest. The streams present a natural corridor for aquatic and terrestrial biota across disturbed landscapes, and ecological understanding of these off-reserve habitats is crucial to long-term management of biodiversity within disturbed landscapes and in the whole region.

Task (iii) ***Guidelines for best practice stream-based recreation in the Wet Tropics*** is due for completion early in the 2001/02 year. Supplementary funding has been sought from the CRC to complete the project, and no new proposal is included here.

Task (iv) ***Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams*** is nearing completion, and as no new funding is sought for an extension, no proposal is presented here

Task (i) ***Road drainage, road crossings, water quality and stream*** addresses a need expressed by consultants at a workshop in 1999. Currently there is no quantification of the effects of road crossings, although it is assumed that they have detrimental effects on water quality and biota through, amongst other impacts:

- sedimentation resulting from road drainage or bed disturbance; this can be particularly severe at crossings through streams and at bridges or culverts under gravel roads;
- input of contaminants from roads including chemicals derived from oil, rubber, etc.;
- opening of canopy providing large patches of light;
- presenting barriers to movement of instream invertebrates and fishes (see also Sub-project 3).

This project will select a number of crossing types (e.g. courseways, culverts and bridges, and sealed and unsealed roads, each with examples of different levels of usage), and analyse water quality and sediments at several sites in a series upstream and downstream of the crossings before, during and after rain events. It will document the biota (plants, invertebrates and fishes) at upstream and downstream sites. The outcomes will be a classification of crossings on the basis of structural and usage type, related to levels of impact. Experimental treatments will demonstrate these impacts, which will be quantified within gradients of selected crossing types. Guidelines to best practice design of stream crossings to sustain water quality and biodiversity values will be produced, in concert with the outputs of Sub-project 3.

Task (v) ***Invertebrate/flow relations in Wet Tropics streams*****.**
There is now a substantial body of research that addresses environmental flow requirements in relation to habitats and fish communities in the Wet Tropics. However, the issue of flow needs for invertebrate communities has not been directly addressed. While previous work clearly indicates that flow regime dictates habitat which in turn acts as a template that determines the invertebrate community, it is not clear to what extent flow regimes must be varied to cause changes in the template and the community. This is an important issue because invertebrate communities represent a large proportion of the biodiversity in streams, they are vital links in food webs, and they are the predominant or even the only fauna living in the thousands of kilometres of small upland streams.

Current data from a range of sampling programs associate community composition with particular flows; however, there is no experimental test to verify and quantify the relationships. This subproject addresses this issue by experimentally manipulating flows under a series of different regimes, ranging from natural through various artificial scenarios (based on real situations). It will test hypotheses derived from parallel studies focussing on fish and fish habitats and thereby aim to develop an integrated view of environmental flow requirements and management guidelines for Wet Tropics streams from source to mouth. The methodology will involve flow manipulations *in situ* using our current standardised benthic sampling protocols, and artificial stream channels, as appropriate.

Work plan

Operating year:	**99/00**				**00/01**				**01/02**				**02/03**				**03 >**
Calendar year quarter:	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	
Task (i) (Crossings and water quality)																	
Review of topic					X	X											
Classification of crossing types											X	X					
Field work											X	X	X	X			
Targeted experiments						X	X						X	X	X	X	
Report and guidelines																	XX

Operating year:	**99/00**				**00/01**				**01/02**				**02/03**				**03 >**
Calendar year quarter:	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	
Task (ii) (Canefield drainage and water quality)																	
Review	X	X															
Field work			X	X	X	X	X	X	X	X	X	X					
Experiments																	
– dissolved oxygen acute effects			X	X	X	X	X	X									
– dissolved oxygen sublethal effects							X	X	X	X	X	X	X	X	X	X	
Workshop – agriculture and water quality														X			
Report and guidelines (draft and final)													X	X			XX
Task (iii) (Stream ecotourism and water quality)																	
Data collection/processing	X	X	X	X	X	X											
Technical workshops							X										
Technical reports								X	X								
Information sheets									X								
Task (iv) (Monitoring and assessment)																	
Data collection/processing	X	X	X	X	X	X	X	X	X	X							
Technical report – WT invertebrates											X						
Technical report – monitoring protocols for WT streams												X					
Task (v) (Invertebrates and flow)																	
Review											X	X					
Field work												X	X	X	X	X	
Field experiments													X	X	X	X	XX
Technical reports																	XX

Milestones (to 01/02 year)

Task		Milestone	Due date for completion
(i)	1.	Paper on sediment effects on invertebrates	07/01
	2.	Classification of crossing types and associated environmental quality	06/02
(ii)	3.	Paper on acute effects of dissolved oxygen on invertebrates	07/01
	4.	Paper on acute effects of dissolved oxygen on fishes	10/01
	5.	Workshop – agriculture and water quality	11/02
	6.	Draft technical report	12/02
(iii)	7.	Technical workshops	05/01
	8.	Technical reports	09/01
	9.	Information sheets	09/01
(iv)	10.	Paper on impacts of forest conversion on streams	07/01
	11.	Technical report – WT stream invertebrates	03/02
	12.	Technical report – stream monitoring protocols	06/02
(v)	13.	Review paper on invertebrate/flow relations	06/02

Communication Plan

Workshops have been held or are programmed to help define tasks and to enhance products. Each task will produce several levels of communication including publication in the scientific literature, technical reports targeted at specific audiences (eg. guidelines for managers), and information sheets where appropriate.

Key References

Government of Queensland 2000 *Water Act 2000*, Qld Government, Brisbane.

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APPENDIX E - PROJECT 5.1 DESCRIPTION

Title Management strategies and monitoring tools for stream restoration and flow management

Key Researchers B.J.Pusey (GU), A.H.Arthington (GU)

Duration **Start** 2001 **End** 2005

Background/Relationship to CRC and Program goals

Understanding the patterns and causes of the distribution of organisms is a key goal of ecology and a fundamental requisite in management. Possessing tools that allow the distribution of individual species to be modelled and predicted further enhances the ability of managers to understand patterns of distribution and allows them a rare opportunity to better manage key species. This project aims to provide that understanding and those tools by examining the distribution of freshwater fishes in the Mulgrave and Johnstone rivers and determining the factors that drive the observed variation in assemblage structures, individual species' distributions and abundance, and collective properties of assemblages such as diversity, density biomass etc.

The Mulgrave/Russell River and the Johnstone River collectively contain a large number of species endemic to the Wet Tropics region as well as containing the most diverse fish assemblages of any Australian river. Quantitative data has been collected for 150 sites of which 22 sites were quantitately sampled on 10 occasions over a five year period encompassing a range of flow conditions.

Whilst essentially descriptive in nature, the proposed research will provide a great deal of information on the distribution and habitat requirements of the fishes of these rivers as well as information on the way the fauna responds to temporal variation in discharge and habitat structure, and to disturbance (two 1/20 year floods and an extended period of low flow occurred during the study).

The proposed project will examine the spatial and temporal organization of fish communities at several different scales and foci:

1. Variation at intermediate spatial scales.

This unit will examine the distribution of fishes within the Johnstone and Mulgrave rivers and focus on the landscape attributes that determine distribution. This unit will complement previous research that has examined spatial distribution of fishes at larger scales such as that of the Wet Tropics region (Pusey and Kennard 1996) and that of north-eastern Australia (Pusey *et al.* in review). Studies at this intermediate scale are useful for drawing together biogeographic effects due to evolutionary history and landscape evolution and those landscape effects which are more contemporary and related to organismal biology. The Johnstone and Mulgrave rivers are ideal study rivers as they differ greater in landscape attributes (ie. river profile, presence of waterfalls, high elevation Tablelands etc.).

2. Variation in abundance and structural characteristics of fish assemblages at different spatial scales.

Previous research by us (Pusey *et al.* 2000, unpublished data) has shown that landscape effects have the greatest effect on determining the presence or absence of species and little additional effect on the abundance of species. *In-situ* characteristics of each site were found to more strongly determine abundance. This unit will examine spatial variation in abundance and such structural characteristics as diversity, biomass, size structure and species richness and relate such variation to variation in habitat structure. The data set available includes habitat data comprised of 20 different variables (eg. water velocity, depth distributions, substrate composition, riparian cover, availability of cover etc) collected in a rigorous random points sampling design for each site. The data set allows us to examine

spatial variation at a variety of spatial scales such as pool *versus* riffles, tributaries *versus* main channel, upland streams *versus* lowland streams, forested *versus* cleared and river *versus* river. This latter comparison is of considerable interest as preliminary comparisons for a number of species indicate that density levels in the Johnstone River exceed those observed in the Mulgrave. It is proposed here that such differences reflect differences in catchment lithography (basalt *versus* granite/ metamorphics) with attendant effects of stream productivity. It is possible to test this hypothesis using the CRC's GIS data base to characterise the lithology of each subcatchment for which we have fish data. It may also be possible to link this small component with invertebrate research undertaken by other CRC researchers.

In addition, we also have an equivalent data set for sub-tropical rivers of south-eastern Queensland and therefore have an opportunity to examine variation in structural characteristics over large spatial scales also.

3. Temporal variation in structure and structural characteristics of fish assemblages

Sequential sampling at individual sites has generated a large amount of data on the temporal dynamics of individual species abundances and assemblage levels characteristics. Such variation may be related to variation in habitat structure which is most strongly dependent on flow regime variation. This unit allows a rigorous assessment of how changes in stream flow impact on fishes and is therefore of great relevance to environmental flow management. The data covers a range of antecedent flow conditions including one extended period of low flows plus two large floods (>1 in 20 yr events).

4. Modelling the distribution of fish species in the wet tropics region.

Pusey *et al.* (2000) addressed issues concerning the development of models to predict spatial variation in freshwater fish assemblage structure. The models were based on a combination of ordination, classification and multiple discriminant functions analysis and predictor variables included a range of landscape scale variables such as catchment area, gradient, elevation etc, as well as variables pertaining to habitat structure at the meso- and micro-habitat scale. This study demonstrated that assemblage structure was predictable based on knowledge of habitat structure and that the degree of predictability varied according to how the assemblages were characterised (ie. presence/absence or density) and according to which variables were used as predictor variables.

Assemblages characterised by presence/absence of individual species were largely predictable using landscape variables whereas the addition of meso- and micro-habitat variables was required to achieve maximum predictive value for assemblages characterised by the density of individual species. These results suggest that the distribution of species is largely controlled by landscape scale features whereas density is more strongly determined by the microhabitat characteristics of a particular location.

The results also indicated that fish assemblages in the Wet Tropics are only weakly organised as assemblages *per se* (ie. they are **not** unit discrete communities) and all members of an assemblage do not respond to variations in habitat conditions in the same manner, despite the predictive power of the models. Models based on the distribution and abundance of **individual species** are therefore more likely to have greater predictive power. Moreover, multivariate models, while interesting and informative, are cumbersome to use in the routine management of aquatic systems and apply only to those rivers in which they are developed. Single species models are more likely to be useful for management purposes.

The aim of the proposed unit of research is to complete spatial modelling of individual species. Data is available for at least 30 species. Some field sampling may be required to assess the predictive power of the models in adjacent systems, but this will be a relatively minor component.

5. Development of an Index of Biotic Integrity for Rainforest Streams

There has been a recent worldwide focus on the development of rapid assessment methods for the estimation of ecological health. Freshwater fishes have been proposed as good indicators in such methods (i.e. Index of Biotic Integrity or IBI) but such methods are only effective if based on sound empirical underpinnings. The research proposed above will provide that empirical background. This unit will draw together all of the above research to formulate a rapid assessment method specifically tailored for streams of the Wet Tropics region. It will contain guidelines on sampling methods and a detailed method for combining fish assemblage and habitat structure data to form an **Index of Biotic Integrity for Rainforest Streams.** This method, coupled with the predictive models, plus the results of other research undertaken by members of the CRC and CCISR (Mark Kennard, PhD student supervised by BJP and AHA) – "Development of rapid assessment protocol using fish in south-eastern Queensland, a subproject in CRC Program 5 – Trophic diversity of Australian freshwater fishes, and DNR funded project – "Review and development of rapid assessment protocols" (AHA as Research Team Leader) will provide a powerful tool for managers. Our methods will supplement those developed for invertebrates (Prof. R. Pearson *et al*, JCU) and for riparian vegetation (G. Werren, JCU).

Potential applications of the research

The proposed research will have five key outcomes and applications, as follows:

- Increased understanding of the processes that organise and structure freshwater fishes of the Wet Tropics region
- Allow the identification of key habitats that support high biodiversity or endemism or those habitats that critical in the maintenance of species populations and/or diversity
- Allow the identification of key processes that structure fish assemblages so that future development may occur without detriment to existing fish communities
- Allow an assessment of the effects of temporal variation in flow regime on the maintenance of biodiversity and fish populations and thus allow effective environmental flow management in the future
- The development of a rigorous assessment method for the rapid appraisal of environmental health in the rivers and streams of the Wet Tropics region.

Objectives

The objectives of this sub-project are to:

- use existing data sets to elucidate the processes of greatest importance in structuring the fish communities of two rivers of the Wet Tropics region
- provide an empirical basis for sound environmental flow assessment and management in rivers of the Wet Tropics region
- provide a rigorous method for the rapid assessment of ecological health in rainforest streams of the Wet Tropics region using fish as indicators.

Outputs

The proposed research will have three types of outputs, as follows:

- A series of international journal articles
- Incorporation of information in case study of river management of the Mulgrave River being organised as a major initiative between WTMA and Program 1.3 of the CRC
- Information sheets and manual describing **IBIRS** (an Index of Biotic Integrity for Rainforest Streams) for use by management agencies.

Linkages/ Collaborators

Project type	Nature of linkage
Within CRC	Pusey and Arthington linked with CRC Project 5.2 and Program 6, and outputs from Project 1.3.1 relating to restoration and management of aquatic fauna / flora
Other	WTMA, NR&M and Qld EPA – linkages with regional activities of these Stakeholders.
	Collaboration with members of the CRC for Freshwater Ecology – Flows Program.

Who are the key stakeholders?

(1) User groups represented on the Program Support group, and participating in regular meetings.

(2) Government agencies responsible for conservation and land management (stakeholders on behalf of the community at large, which has politically shown its interest in ensuring that there is ecologically sustainable land cover): Qld Dept of Natural Resources, Qld Environment Protection Agency, Qld Parks and Wildlife Service, Wet Tropics Management Agency, Qld Forestry Research Institute, Qld Dept of Primary Industries.

(3) Other organisations, including NGO's (having an active interest in achieving ecological sustainability through conservation and restoration): World Wide Fund for nature; North Qld Afforestation Association Inc; Greening Australia.

Work Plan

The fieldwork required for this project have been collected over the period 1994-1998 and there is therefore little additional field work required. Consequently, most work required is analytical and the production of written material. The table below summarises the expected progress and lists products (journal articles, etc.) as each task to be undertaken.

	01/02				02/03				03/04				04/05			
Task	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Spatial organization of fishes in the Mulgrave and Johnstone Rivers																
- analysis	X	X	X													
-production of manuscript				X	X											
Mesoscale effects of habitat structure on fish abundance and structural characteristics of fish assemblages																
- analysis					X	X										
- production of manuscript							X									
- analysis								X	X							
- production of manuscript										X						
Effect of catchment lithology on fish communities																
- analysis											X	X				
- production of manuscript													X			
Development of a rapid fish assessment protocol for use in the Wet Tropics region																
- analysis													X			
- production of manual and information sheets													X	X	X	X

Milestones

The key tasks listed above are discrete enough to be used as milestones for inclusion and reporting against in the CRC annual report.

- A series of international journal articles.
- Incorporation of information in case study of best practice catchment management (Mulgrave River) proposed as a major initiative of Program 1.3 of the CRC.
- Information sheets and manual describing IBIRS for use by management agencies.

Key references

Pusey, B.J., Kennard, M.J. and Arthington, A.H. 2000, Discharge variability and the development of predictive models relating stream fish assemblage structure to habitat in north-eastern Australia, *Ecology of Freshwater Fish* 9: 30-50.

APPENDIX F - PROJECT 5.2 DESCRIPTION

Title: Biodiversity of aquatic macrophytes and bryophytes in aquatic habitats of the Wet Tropics Bioregion

Key Researchers B.J.Pusey (GU), A.H.Arthington (GU), G.Werren (JCU), A.Cairns (JCU), S.Mackay (GU)

Duration **Start** 2001 **End** 2005

Background/Relationship to CRC and Program goals

Much progress has been made in documenting the biodiversity of aquatic organisms in the Wet Tropics region over the last two decades. This research has focussed primarily on invertebrates, fishes and amphibians and has largely ignored aquatic flora. For example, Jacobs and Wilson (1996) analysed 553 species of aquatic plants in Australasia and included bryophytes in their survey yet no bryophytes were listed for Papua New Guinea or north Queensland. This is a surprising omission as elsewhere in the tropics rich and distinctive bryophyte floras have developed (Buck and Thiers 1989) and probably reflects of the lack of published data on aquatic bryophytes in north Queensland rather than true absence. Aquatic macrophytes have been similarly overlooked (with the exception of recent description of new species within the genus *Aponogeton*) and this has led to some serious and depressing consequences for some species (see below). The 'rare' conservation status of *Vallisnaria nana*, for example, reflects a great range disjunction of the sparse north Queensland and south-east Queensland records in the Queensland Herbarium and is likely indicative of the low representation of aquatic macrophytes in the collection (Forster, pers. comm.).

The Wet Tropics region is acknowledged as a region of extremely high biodiversity and endemism of aquatic invertebrates (Pearson 2000) and fishes (Pusey and Kennard 1996). One of the possible causes may be because aquatic environments of the region were not impacted by climatic changes during the Pliestocene (Pusey *et al*, in review). It seems unlikely therefore that a rich macrophyte and bryophyte flora has not also developed and persisted in streams of the Wet Tropics. This inference is supported by the recent systematic review of the *Aponogeton* in which the four species present in the Wet Tropics region (*A. bullosus, A. lancesmithii, A. prolifera* and *A. vanbruggenii*) were shown to be endemic.

Aquatic macrophytes and bryophytes may be particularly sensitive to human-induced disturbance (Glime 1992). For example, the removal of mature rainforest trees by logging increases the sand load of forest streams, resulting in the destruction of bryophyte habitats (Gradstein 1992). Slack and Glime (1985) nominated taxa inhabiting springs and rivulets as being especially vulnerable to prolonged drought, which may be attributable to anthropogenic sources. Studies of riparian communities have shown that bryophytes are highly susceptible to changes in flow (Englund 1991). Similarly, aquatic macrophytes have been shown to be sensitive to organic and inorganic pollution (e.g. Vanderpoorten and Palm 1998; Vanderpoorten 1999), changes in flow regime (Blanch *et al.* 1999; French and Chambers 1996; Rørslett *et al*. 1989) and other anthropogenic disturbance. For example, one of the recently described endemic *Aponogeton* species, *A.prolifera*, is officially classified as 'endangered' but may already be extinct in its natural habitat due to uncontrolled collecting by plant enthusiasts. The remaining *Aponogeton* species are classified as either vulnerable or rare/restricted.

Bryophytes of tropical rainforests and tropical montane forests have been noted by Koponen (1992) as under threat from disturbance. For many species it is not known whether bryophytes are rare or undercollected; many are known only by the type specimen (Koponen 1992). Clearly, the distribution and composition of the aquatic flora of the region needs to be assessed, and in the case of some species, such effort needs to occur quickly.

The conservation of aquatic flora of the region is important for reasons other than the maintenance of plant biodiversity. Aquatic plants form an important microhabitat for many other stream organisms. In-stream mosses and liverworts have been shown to play significant roles as habitat for invertebrates, offering refuge and protection from predators and high flows (Egglishaw 1967; Glime 1994; Malmqvist and Sjostrom 1984), hunting areas for small predatory nymphs (Malmqvist and Sjostrom 1984), and trapping organic matter used for food. They may also be an important egg-laying habitat (Glime 1994). Invertebrate densities are often many times greater in moss communities than adjacent substrate (Brusven *et al*. 1990) and greater in submerged mosses than in semi-submersed mosses (Nolte 1991). Similar studies on the roles of bryophytes in relation to macroinvertebrates and microfauna in tropical regions are notably absent. Similar findings have been reported for aquatic macrophytes although their role as habitat extends to fishes also, particularly for larval forms (Pusey *et al* 2001, Pusey *et al.* in review). In addition, aquatic plants are frequently consumed by freshwater fishes and form a significant component of the adult diet of such recreationally important species as sooty grunter (Pusey *et al.* 1995).

The utility of aquatic plants as bioindicators is becoming increasingly recognized as they are sensitive to high nutrient levels (Vanderpoorten and Palm 1998) and heavy metal pollution (Vanderpoorten 1999). Klein and Vanderpoorten (1997) found that different bryophyte communities in riparian forests were related to particular hydrological conditions and humidity levels and could be used as indicators of the impacts of future water management proposals. Similarly, members of CCISR and JCU have collaborated in the development of rapid assessment protocols using aquatic plants as indicators of ecological condition in north-eastern Australian streams.

The biodiversity of aquatic macrophytes and bryophytes in aquatic habitats of the Wet Tropics urgently needs to be assessed in order to define species distributions, identities, conservation values and threats to that biodiversity. In addition, threats to the biodiversity of aquatic plants mean attendant threats to other biota. Furthermore, aquatic plants must be considered in the management of the region's aquatic biological resources. For example, aquatic macrophytes are routinely included in assessments of stream conditions undertaken as part of WRPs, and their ecological requirements are an integral consideration in the setting of Environmental Flow Limits.

Potential applications of the proposed research

1. Increased understanding of the biodiversity of the Wet Tropics region.
2. Increased understanding of the threats to the continuing maintenance of that biodiversity.
3. Increased ability to manage aquatic plant resources and incorporation of plants into management strategies for rivers, particularly those relating to environmental flow management.
4. Incorporation of aquatic plants into rapid assessment protocols for use by agencies charged with aquatic system management.

Objectives

The objectives of this sub-project are to:

- survey the aquatic plants of major aquatic habitats of the Wet Tropics region
- describe the distribution of aquatic plants within the WT region
- characterise the microhabitat requirements of aquatic plants of the region
- characterise the threats to the region's aquatic flora
- incorporate aquatic flora more fully into management options, conservation planning and monitoring programs

Outputs

It is envisaged that a series of international journal papers will result from this research. These will include articles on distribution, habitat requirements, conservation and threats. Taxonomic articles may also result.

Data on plants and management issues in the Mulgrave catchment will be taken up into the collaborative Project - Case Study in Best Practice Catchment Management.

Fact Sheets will also be produced for incorporation into the CRC's program of information dissemination.

A booklet will be produced for agencies such as WTMA, DNRM and QDPI Fisheries describing and illustrating the major components of the flora, their importance and their management.

Linkages/ Collaborators

Other project type	Nature of linkage
Within CRC	Pusey and Arthington linked with Project 5.2 and Program 6: across program research and to outputs relating to design features required for restoration and management of aquatic fauna and flora
Other	WTMA and Qld EPA - possible linkages with regional activities of these Stakeholders. Collaboration with members of the CRC for Freshwater Ecology - Flows Program and via postgraduate student Steve Mackay. Collaboration with members and associates (e.g. Dr Thorsten Mosisch, aquatic plant ecology) of the Centre for Catchment and In-Stream Research, Griffith University.

Who are the key stakeholders?

User groups represented on the Program Support group, and participating in regular meetings

(a) Government agencies responsible for conservation and land management (stakeholders on behalf of the community at large, which has politically shown its interest in ensuring that there is ecologically sustainable land cover): Qld Dept of Natural Resources, Qld Environment Protection Agency, Qld Parks and Wildlife Service, Wet Tropics Management Agency, Qld Forestry Research Institute, Qld Dept of Primary Industries.

Project has the in-principle support of WTMA (Dr Max Chappell) and Qld EPA (Dr Julia Playford, Director of Research)

(b) Other organisations, including NGO's (having an active interest in achieving ecological sustainability through conservation and restoration): World Wide Fund for nature; North Qld Afforestation Association Inc; Greening Australia.

Research Strategy and Proposed Methods

Field survey work is expected to commence in the latter half of the 2001 calendar year and will, at first, focus on the Mulgrave and Johnstone catchments. The reasons for this are many. First, incorporation of aquatic flora information into any proposed management case study as is proposed for the Mulgrave is highly desirable and logical. Second, aquatic bryophytes have been collected by A.Cairns in the Johnstone River as part of a JCU project concerning groundwater arising from the Atherton basalts. Third, both are known to contain certain rare, restricted, vulnerable or endangered species (ie. *Aponogeton* spp. and *Torrenticola queenslandica*) and characterisation of their distribution and habitat requirements should be of high priority. Fourth, these two rivers are rich in endemic fish

species implying the continued presence of flowing water throughout the Pleistocene. Such rivers may contain endemic or rare plant species also. Differences in catchment lithology, land use and landscape (e.g. presence of tablelands, river profile) of these two adjacent systems allows good opportunity to examine the factors determining distribution and provide useful insight when the project is expanded to include other rivers to the north and south. Finally, the Mulgrave catchment is proposed as the collaborative Project 1.3 Case Study in Best Practice Catchment Management.

The survey work will then be expanded to include a select number of other rivers of the Wet Tropics Bioregion. The choice of rivers will be decided upon after examination of Herbarium records to determine likely "hotspots" of biodiversity, but at the least will include the Herbert, Tully, Daintree and Bloomfield rivers and the upper Mitchell and upper Normanby Rivers.

Field methods will involve standard aquatic plant sampling techniques and collection of associated habitat data (eg. Mackay and Thompson 2000). Site lengths of approx. 100 m of include all habitat types per geomorphological catchment zone will be surveyed in sections of 20m; this has been shown to maximise aquatic plant diversity (Mackay unpublished data).

Work Plan

Task	01/02				02/03				03/04				04/05			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Conduct field work in the Mulgrave and Johnstone rivers		X		X	X											
Identify material, analyse data			X	X	X	X										
Prepare manuscript on distribution and habitat requirements					X	X	X									
Conduct field work in expanded selection of rivers							X			X	X					
Identify material, analyse data								X	X	X	X					
Prepare manuscript on the aquatic flora of the Wet Tropics region												X	X	X		
Prepare manuscript on conservation status and threats to aquatic flora of the WT region														X	X	
Prepare information sheets and booklet								X	X	X	X	X	X	X	X	X

Milestones

The key tasks listed above are sufficiently discrete to be used as milestones for inclusion and reporting against in the CRC Annual Report. They are:

- series of international journal papers
- Incorporation of information in case study of best practice catchment management (Mulgrave River) proposed as a major initiative of Program 1.3 of the CRC.
- Information Sheets
- booklet will be produced for agencies such as WTMA, QDNR and QDPI Fisheries describing and illustrating the major components of the flora, their importance and their management.

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APPENDIX G - PROJECT 6 DESCRIPTION

Title Best Practice Catchment Management: Mulgrave River Case Study

Key Researchers A.H. Arthington (GU), J.C. Patterson (JCU), R.G. Pearson (JCU), I. R. Kapitzke (JCU), B.J. Pusey (GU), G. Werren (JCU)

Duration **Start** 2001 **End** 2005

Background/Relationship to CRC and Program Goals

Integrated catchment management is the goal of natural resources management in Australia and is equally relevant in the Wet Tropics Bioregion, where many forms of land and water use may occur in catchments and sub-catchments. Different parts of sub-catchments are usually under disparate forms of land use, tenure and protection, and subject to many different types of stress and disturbance. How best to assess and manage these disturbances to improve physical stream condition and restore biological communities and stream ecosystems is a major challenge for agencies and communities. Streams and rivers are characterised by longitudinal, lateral and surface to groundwater linkages and processes, set in a matrix of spatial and temporal variability. All of these interactions must be considered in management planning, and in the planning and design of infrastructure, either for development or rehabilitation. Frameworks and models to achieve integrated management are rare, and there is presently no clear set of guidelines on what might constitute 'Best Practice" in freshwater resources management in the Wet Tropics Bioregion. Major issues are usually considered individually as isolated programs of research and action (eg. riparian restoration, water quality management, environmental flows) and outcomes for a catchment may be fragmented and inadequate to protect the component ecosystems.

This project offers the CRC an opportunity to draw together outputs from many projects within the Research Project (see R&D Chart), some of the broader elements of Program 1, and possibly, outputs from Programs such as 5 and 6, as well as many other sources of published information.

The overall aim is to produce a framework for integrated catchment management, including assessing stream bank, riparian and in-stream condition and deciding on priorities and techniques for restoration and other on-ground works, and then testing outcomes of selected works via research and monitoring, leading to development and collation of a set of "Best Practice" guidelines, protocols, manuals etc for planning and management at catchment scale in the Wet Tropics Bioregion.

The project will focus on the Mulgrave catchment in the Wet Tropics Bioregion, building on previous scientific, management and planning studies (eg. *Russell-Mulgrave Catchment Rehabilitation Plan*), as follows.

Scientific Studies

Much progress has been made in documenting the biodiversity of aquatic organisms in the Wet Tropics region over the last two decades. This research has focussed primarily on invertebrates, fishes and amphibians. In the following sections, the knowledge base and its relevance to the Mulgrave River Case Study are outlined.

Aquatic Macrophytes

The Wet Tropics Bioregion is acknowledged as a region of extremely high biodiversity and endemism of aquatic invertebrates (Pearson 2000) and fishes (Pusey and Kennard 1996). One of the possible causes may be that aquatic environments of the region were not greatly impacted by climatic changes

during the Pleistocene (Pusey *et al*, in review). It seems likely therefore that a rich macrophyte and bryophyte flora has developed and persisted in streams of the Wet Tropics.

Biodiversity research in the Wet Tropics Bioregion has largely ignored aquatic flora. For example, Jacobs and Wilson (1996) analysed 553 species of aquatic plants in Australasia and included bryophytes in their survey yet no bryophytes were listed for Papua New Guinea or north Queensland. This is a surprising omission as elsewhere in the tropics rich and distinctive bryophyte floras have developed (Buck and Thiers 1989) and probably reflects of the lack of published data on aquatic bryophytes in north Queensland rather than true absence. Aquatic macrophytes have been similarly overlooked (with the exception of recent description of new species within the genus *Aponogeton*).

A new CRC research (Sub-project 5.2: *Biodiversity of aquatic macrophytes and bryophytes in aquatic habitats of the Wet Tropics Bioregion*) proposed for startup in 2001-2002, will provide much essential information into the Mulgrave River case study.

Riparian Vegetation

Apart from the quantum of water, there is no factor more significant to maintenance of stream ecosystem health than riparian vegetation, which influences a great range of features associated with streams and other wetland systems.

"The importance of riparian systems far exceeds their minor proportion of the land base because of their prominent location within the landscape and the intrinsic linkages between terrestrial and aquatic ecosystems. Fluxes of water, air masses, dissolved and particulate matter, and organisms across a landscape are channeled into and along valley floors. Interactions between terrestrial and aquatic ecosystems include modification of microclimate (eg, light, temperature, and humidity), alteration of nutrient inputs from hill-slopes, contribution of organic matter to streams and floodplains, and retention of inputs" (Gregory et al. 1991:544).

Influences range from structural controls on channel form, hydraulic conductivity and erosion and sediment/nutrient transport, through direct influences on water quality, and primary carbon sources for aquatic system production to productivity and biodiversity 'hotspots', wildlife refuges and corridors within the wider landscape. Riparian vegetation influences a great range of features associated with streams and other wetland systems. Gregory *et al*. (1991) argue that riparian plant communities offer an abundant array of food resources for both aquatic and terrestrial consumers that are reliably present in the landscape. Such areas usually support a greater array of species in higher abundance that elsewhere in the landscape and are considered both productivity and biodiversity 'hotspots'. While riparian corridors are commonly recognised as animal movement corridors they also play a potentially significant role in the dispersal of plants. Clearly water moving along a channel can transport plant fruits, seeds and stem fragments that can establish downstream. In addition, riparian zones can be major sources of plant recruitment over extensive areas of the landscape, especially during periods of rapid climatic change because of the favourable microclimate along stream valleys (Gregory *et al*. 1991:543).

The catchment of the Mulgrave River lies to the immediate south of the major regional city of Cairns, Far North Queensland, in the central eastern section of the bioregion. The river drains a major part the Bellenden Ker Massif of the Great Dividing Range emerging from the ranges to flow south-south-east along a narrow coastal valley to join the Russell River before breaching the coastal Malbon-Thompson and Graham Ranges to flow into the Coral Sea at Mutchero Inlet. The catchment receives a high/very high annual rainfall ranging from less than 1 900mm at Meringa to more than 8 000mm at the summit of Mount Bellenden Ker (Tracey 1982). While a great proportion of the catchment consists of the dense rainforests of Wooroonooran National Park, the middle to lower reaches traverse major cane-growing concessions served by Mulgrave Central and Babinda Mills. Riparian vegetation has been damaged along some headwater streams arising on the Atherton Tableland, but it is

along the lower floodplain sections of the system where loss and disruption of the riparian verge has been extensive. Rainforest and paperbark (*Melaleuca leucadendra*) gallery forest has been removed and fragmented along the lower reaches that flow through these intensively cultivated lands. Ecological implications for the health of streams associated with such disturbances are discussed in Arthington *et al.* 1997).

Along the middle to lower reaches of the Mulgrave and other river systems the riparian verge and associated wetlands often support the bulk of the remnant vegetation of that part of the district, with the remainder having ceded to cane farms. Moreover, these occurrences contain threatened regional ecosystems such as 'endangered' complex rainforest, palm (*Archontophoenix alexandrae, Licuala ramsayi*) and paperbark (*Melaleuca* spp.) dominated vine forest communities and others such as swampy sedgelands dominated by *Eleocharis dulcis*, paperbark swamps and semi-deciduous notophyll riparian rainforest on well-drained alluvial levées (Goosem *et al.* 1999) that are officially listed as 'of concern'.

These systems also contain at least 65 rare and/or threatened plant species (Werren, unpub. data). Examples include the 'endangered' *Lycopodium dalhouseanum* and *Dendrobium nindii* and 'vulnerable' *Canarium acutifolium* var. *acutifolium, Lastreopsis walleri, Macaranga polyadenia, Huperzia lockyeri, H. phlegmarioides, H. prolifera* and the ant plant *Myrmecodia beccarii*. At least 55 species are officially listed as 'rare/restricted' and there are several other that are poorly known. Some, such as the 'endangered tassel fern *L. dalhouseanum*, the 'vulnerable *C. acutifolium* var. *acutifolium* and 'rare' tinkling satinash (*Syzygium alatoramulum*) are essentially confined to the riparian zone within the Mulgrave catchment.

The condition of riparian vegetation of the catchment was synoptically reviewed by one of the proposed study team members (GW) in the *Russell-Mulgrave Catchment Rehabilitation Plan*. This was formulated under the auspices of the North Queensland Joint Board (1998) to facilitate coordinated catchment management and rehabilitation. While the riparian verges of streams of the upper catchment are largely intact, the middle to lower reaches are characterised by significantly disrupted riparian communities, and, in places from the confluence with the Little Mulgrave River to immediately upstream of the intertidal communities of Mutchero Inlet where it meets the Russell, the fringing forests have been extensively cleared and wetlands have been drained.

Notable also, is the particular susceptibility of riparian systems to exotic species invasion (Humphries and Stanton 1992:viii; Pysek and Prach 1993) similarly document the high invasibility of these systems elsewhere in the world . Baker (1986:48) also confirms this and other workers such as Décamps *et al.* (1988, 1995) also discuss this issue in detail. This is significantly evident along lower reaches of the Mulgrave system where highly invasive species such as cucumber tree (*Parmentaria aculeata*) and leucaena (*Leucaena leucocephala*) form monospecific stands adjacent to the river (NQ Joint Board 1998).

Riparian systems have an intimate connection with in-stream systems and appear to be sensitive indicators of environmental change. Riparian attributes should therefore contribute candidate metrics in any comprehensive measure of stream condition and change, yet assessment of the condition of riparian vegetation in monitoring programs aimed at ascertaining river ecosystem 'health' is not well advanced. Werren and Arthington (2000) reviewed methodologies aimed at assessment of the contribution of riparian vegetation to river 'health', including integrated assessment protocols employed by government agencies, techniques developed from particular research perspectives as well as within multi-disciplinary approaches to riverine condition assessment. While some approaches currently in use hold promise, there is no suitable protocol for rapid riparian vegetation assessment that can be incorporated into a multi-metric index of stream condition, or used to assess the impacts of flow regulation, in particular, on ecosystem integrity. Werren and Arthington (2000), however, propose a standard multi-metric approach to rapid assessment of riparian vegetation as distinguished from the more detailed methods applied in longer-term research programs. This approach was

configured to assist in determining stream condition and the extent of flow regulation impacts. It provides positive and negative benchmarks against which water infrastructure and other developments, and stream rehabilitation measures can be assessed in a manner to progress ecological sustainability in streams in this and other regions of the State.

The proposed development of more comprehensive methods for assessment of the condition of riparian vegetation (*Riparian Vegetation Manual: Condition Assessment and Priorities for Rehabilitation*, Arthington, Catterall and Werren) is also highly relevant to this study. The research currently being undertaken by Lukacs *et al.* (ACTFR) on water use by riparian vegetation is also directly relevant to this proposed study. Using stable isotope and plant physiology techniques, this study is providing a new approach in the determination of the environmental flow needs of riparian systems in the Wet Tropics.

The priorities and methods for rehabilitation of degraded riparian zones on the Mulgrave River and other river systems will be linked to research outcomes in Sub-project 2: *Stream rehabilitation protocols and techniques* (Kapitzke *et al*.). This project is developing planning and design protocols for stream rehabilitation from the whole-of-stream scale, to reach and site scales. Sub-project 2 will provide an opportunity to implement, monitor and evaluate rehabilitation techniques at selected sites on the Mulgrave River to address bank erosion, degraded riparian habitat, altered flow regime etc.

Fish, Flow Regime and Aquatic Habitat

The Mulgrave/Russell River and the Johnstone River collectively contain a comparatively large number of fish species endemic to the Wet Tropics region as well as containing the most diverse fish assemblages of any Australian river. Quantitative data has been collected for 150 sites of which 22 sites were quantitatively sampled on 10 occasions over a five year period encompassing a range of flow conditions. CRC Rainforest research is producing a sound understanding of the distribution of freshwater fishes in the Mulgrave River and will determine the factors that drive the observed variation in fish assemblage structure, individual species' distributions and abundance, and collective properties of assemblages such as diversity, density biomass etc. (e.g. Pusey *et al.* 1995a, b; Pusey *et al.* 1997; Pusey *et al*. 2000; Pusey *et al.* in press; Pusey *et al* in review; Pusey and Kennard 1996).

Ongoing CRC research (Sub-project 5.1 *Management strategies and monitoring tools for stream restoration and flow management*) will provide a great deal of information on the distribution and habitat requirements of the fishes of these rivers as well as information on the way the fauna responds to temporal variation in discharge and habitat structure, and to disturbance (two 20 year ARI floods and an extended period of low flow occurred during the study). This work will input to the case study by providing an empirical basis for sound environmental flow assessment and habitat restoration in rivers of the Wet Tropics Bioregion.

The diversity and abundance of freshwater fish in the Mulgrave River and other tropical stream systems is dependent on the distribution and quality of suitable aquatic habitat for fish and other aquatic biota. Furthermore, the fish require unobstructed passage along the main watercourses and tributary streams to migrate between habitats as part of the their normal life cycle behaviour. Sub-project 2*: Stream rehabilitation protocols and techniques* (Kapitzke *et al*.) provides an opportunity to develop, monitor and evaluate aquatic habitat restoration techniques (e.g. channel reinstatement, large woody debris). Techniques for remediation of fish migration barriers at road culverts, which are being developed in Sub-project 3: *Road drainage, waterways and fauna crossings* (Kapitzke *et al*.), will be used to redress problems of fish passage obstruction in the Mulgrave River and tributary streams. New *Acoustic Tag Tracking* equipment recently acquired by Arthington and Pearson (ARC REIF 2000) will be applied to studies on the movements of aquatic organisms at barriers, culverts etc.

The proposed development of methods for stream condition assessment based on fish (Sub-project 5.1 *Index of Biotic Integrity for Rainforest Streams,* Pusey *et al*.) is also highly relevant to this case study.

Aquatic Invertebrates, Water Quality and Flow Regime

One of the crucial problems facing land managers in the Wet Tropics is the relationship between (i) use of the land and water, (ii) its impact on habitat and water quality, and (iii) the attendant effects on the aquatic biota. This issue is important because it is vital to manage environmental quality to sustain current high levels of biodiversity in streams and to maintain a healthy human environment, especially where water is used for human purposes, including domestic supply and recreation. Research into the interactions between species, community and environmental quality has a double purpose. Firstly it allows determination of the environmental requirements of a healthy biota; and secondly it provides for calibration of the biota as an environmental monitoring system.

Research on the ecology of tropical rainforest streams and their invertebrate fauna over the past two decades has laid a sound foundation for the Mulgrave River case study (Pearson *et al*. references). Past research outcomes and ongoing CRC and related research will feed into the Mulgrave case study.

Sub-project 4.1 *Infrastructure: Road drainage, road crossings, water quality and stream biotas* (Richard Pearson and Niall Connolly, JCU; Angela Arthington and Brad Pusey, GU) will address the impact of stream crossings on water quality and aquatic wildlife. The outcomes will be a classification of crossing types on the basis of levels of impact, and guidelines to best practice design of stream crossings. This project links closely with Sub-project 3.

Sub-project 4.2 *Agriculture: Quantifying the effects of cane field drainage on water quality and aquatic fauna* (Richard Pearson and Michael Crossland, JCU), funded by SRDC, includes experimental studies that complement CRC-funded research. The outcomes will include an understanding of the quantitative impact of the sugar industry on lowland tropical streams, and guidelines for reducing impacts through improved management.

Sub-project 4.3 *Recreation and tourism: Guidelines for best practice stream-based recreation in the Wet Tropics* (Barry Butler, Alastair Birtles and Richard Pearson, JCU), has been funded under the Federal ecotourism initiative, and by the CRC. It has examined the effects on water quality of recreational use of streams in the Wet Tropics, and is currently developing models of water quality behaviour for application in improved management. It is also producing a series of publications for managers and the tourism industry on the attractions, ecologically sound utilisation and best practice management of Wet Tropics streams. See also Mosisch and Arthington (1998).

Sub-project 4.4 *Rapid Assessment: Guidelines for monitoring and rapid ecological assessment of Wet Tropics streams* (Richard Pearson, Niall Connolly and Michael Crossland, JCU) is the culmination of a long-term project examining the invertebrate communities of Wet Tropics streams. It will provide a toolbox for managers and consultants for monitoring water quality and habitat integrity using stream invertebrates as indicators of disturbance. Invertebrate methods will complement the biological assessments of stream condition based on riparian vegetation and fish.

Sub-project 2: *Stream rehabilitation protocols and techniques* (Kapitzke *et al*.) provides an opportunity to develop, monitor and evaluate habitat restoration techniques appropriate for aquatic invertebrates.

Management Studies

The project will collate relevant management studies and documents to provide the knowledge base for an assessment of the condition of riparian and in-stream resources in the Mulgrave sub-catchment. This literature will also provide basic data on stream processes (hydrology, hydraulics, geomorphology etc.), infrastructure development and rehabilitation measures for the catchment.

The “Mulgrave River Management Action Plan”, presently being finalised by Natural Resource Assessments for the Cairns River Improvement Trust, is the latest in a sequence of management plans for the catchment and its watercourses, which address community concerns and the desire to integrate resource use with protection of ecological integrity. The Management Action Plan identifies and develops priorities for stream rehabilitation works and management actions along the Mulgrave River, and provides a good foundation for our case study project on stream condition assessment, restoration priorities and techniques, monitoring and performance evaluation.

Whereas conventional stream rehabilitation programs emphasise narrow objectives such as flood and erosion control, stream management plans such as the “Mulgrave River Management Action Plan” must incorporate multiple objectives. This involves integrated environmental management practices, which reflect the vision, goals and objectives for regional and local management plans (e.g. FNQ 2010 Regional Plan; Strategic Plan of the Russell and Mulgrave Rivers). The Mulgrave River plan must address goals for (i) *flood and erosion control*; (ii) *water quality*; (iii) *habitat and conservation*; and (iv) *amenity and cultural values*.

The “Mulgrave River Management Action Plan” follows best practice planning, design and evaluation methodologies for multipurpose stream rehabilitation, in keeping with recent stream rehabilitation planning studies for Liverpool Creek (JRIT and JRCMA 2000), the Barron River (Natural Resource Assessments 2000). Based on rehabilitation protocols and techniques developed in CRC Project 2 *Stream rehabilitation protocols and techniques* (Kapitzke *et al*.), the Mulgrave River and other studies provide good case examples and models for further development of a protocol to be applied throughout the region.

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Potential Applications of the Research

The proposed research will have the following key outcomes and applications:

- Assessment of state of knowledge about Mulgrave River catchment, and need for new R & D.
- Collation of management studies to assist in developing a basis for setting priorities for on-ground works (e.g. channel or riparian restoration, fish habitat restoration).
- An assessment of the ecological condition of riparian and stream ecosystems in the study catchment (funding permitting).

- Collation of “Best Practice” guidelines, protocols and manuals for stream restoration in the Wet Tropics.
- Selected on-ground works will be undertaken and monitored as collaborative projects with CRC Rainforest, other research groups, WTMA, Cairns River Improvement Trust, agencies and community groups.
- Reports, Fact Sheets, leaflets, public demonstrations about “Best Practice” natural resource management in a whole sub-catchment in the Wet Tropics.
- Scientific papers on R&D outcomes.

Objectives

The objectives of this sub-project are to:
- Provide a case study of the issues and priorities for natural resources management on a whole of catchment basis in the Mulgrave catchment or part thereof
- Develop and test planning and design protocols for sustainable infrastructure development, stream rehabilitation and habitat restoration in Wet Tropics streams
- Undertake and monitor selected on-ground works as collaborative projects with CRC, WTMA, agencies and community
- Develop a package of “Best Practice” guidelines, protocols and manuals for stream restoration in the Wet Tropics, with particular reference to water infrastructure developments and flow regulation, the condition of stream banks and the riparian zone, the streams and their biota.

Outputs

The proposed research will have five types of outputs, as follows:
- State of knowledge about Mulgrave River catchments, and need for new R & D.
- An assessment of the ecological condition of riparian and stream ecosystems in the study catchment using existing and new data.
- Demonstrations of selected on-ground works (e.g. riparian or stream habitat restoration)
- A collation of “Best Practice” guidelines, protocols and manuals for stream restoration in the Wet Tropics.
- Scientific papers on R&D outcomes.

Linkages/ Collaborators

Other project type	Nature of linkage
Within CRC	Linked to other activities in Project Pusey and Arthington linked with Project 5.2 and Program 6 of CRC Rainforest and these will deliver outputs relating to design features required for restoration and management of aquatic fauna and flora.
Other	WTMA and Qld EPA - possible linkages with local and regional activities of these Stakeholders. Collaboration with members of the CRC for Freshwater Ecology - Flows Program, Restoration Program, Assessment and Monitoring Program.

Who are the key stakeholders?

User groups represented on the Program Support group, and participating in regular meetings; Water Workshop attendees. Project suggested by Max Chappel, WTMA.

(a) Government agencies responsible for conservation and land management (stakeholders on behalf of the community at large, which has politically shown its interest in ensuring that there is ecologically sustainable land cover): Qld Dept of Natural Resources, Qld Environment Protection Agency, Qld Parks and Wildlife Service, Wet Tropics Management Agency, Qld Forestry Research Institute, Qld Dept of Primary Industries.

(b) Other organisations, including NGO's (having an active interest in achieving ecological sustainability through conservation and restoration): World Wide Fund for nature; North Qld Afforestation Association Inc; Cairns River Improvement Trust; Greening Australia.

Work Plan

This project is under development in concept, work plan and execution. An initial meeting of the key researchers and stakeholders is planned prior to the CRC's Annual Conference, to map out the project in more detail and assign roles, activities and timelines. A Work Plan will be developed from this meeting.

Milestones

The first Milestone will be the outcomes of the project meeting in November 2001 and the Work Plan for the project. The key tasks listed above will be used to develop milestones for inclusion and reporting in the CRC annual report.

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