NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 99 OCTOBER 2001

A NOTE FROM THE DIRECTOR

Professor Russell Mein

Inside...

COOPERATIVE RESEARCH CENTRE FOR

CATCHMENT HYDROLOGY

INTEGRATION - A SPECIAL ISSUE

"Integration will be the biggest challenge for the CRC for Catchment Hydrology".

This statement was made by Dr Tom Hatton (then a CRC Board Member) early in the life of this CRC, at a time when we were putting a draft program of activities together. We were presenting to the Board a set of project outlines, and a big picture view that these (and succeeding projects) would interlink to achieve the general objective of the CRC - predictive capability for land and water managers at a whole-of-catchment scale.

Tom's statement was both perceptive and accurate. It is a big step from formulating individual projects, and their project teams, to having a group of projects that link closely together to achieve an ambitious overall objective. The projects in question involve many disciplines, many research groups, and many cross-linkages. We've had to include risk-analysis in our project planning to minimise the possible threats to our main goal, and to other projects, from setbacks that might occur.

Strategies for integration in the CRC

A key strategy for integration of the CRC's research is the use of focus catchments. In our Business Plan, we nominated the Fitzroy and Brisbane rivers in Queensland, the Murrumbidgee in NSW, and the Goulburn -Broken and Yarra in Victoria, as our focus catchments. The idea is that we direct our research efforts to catchment scale problems in these five basins, and so develop and demonstrate our capability to address important and practical issues. The close involvement of our Parties, and the efforts of the Focus Catchment Coordinators they appointed, has been a significant factor in our success so far.

Another strategy for integration is our aim to develop a catchment modelling toolkit. Essentially this is a scheme to link component models together, in one or more frameworks that can access databases of different kinds (eg GIS topography, rivers and land-use; streamflow and climate) to provide the decision support needed for catchment scale management of hydrology-related issues. Linking of component models of different types and from different disciplines requires a high degree of integration.

How are we doing?

This edition of *Catchword* is devoted to the integration issue. In it, we present our research program from the focus catchment viewpoint. We've asked Program Leaders and Focus Catchment Coordinators to summarise the issues in each catchment, and to outline the relevant and likely impact of the CRC's research in providing the knowledge and tools to tackle them.

There is also a report on the toolkit development, showing some early 'runs on the board'. It is encouraging to see the demonstration applications already in place, for there has been considerable effort made to specify the capabilities of a suitable modelling framework for our needs, and to evaluate existing frameworks in that context.

Closing comment

We have a seven-year program of work planned for this CRC, and have just finished Year 2. In that sense, it is an early stage for an evaluation of our success in meeting the challenge to integrate our research. Getting a better appreciation of the integration issue has been a benefit, however, from preparing the focus catchment and toolkit articles for this special edition of *Catchword.*

Our plan is to have an 'integration issue' of *Catchword* in October each year. Comments from readers on this idea, and on this special issue of our newsletter, are welcome.

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THE CATCHMENT MODELLING TOOLKIT

ROB VERTESSY

THE DIFFICULTY OF CATCHMENT MANAGEMENT

Two of the key features of the CRC's focus catchments are the large size and complexity of each. They vary between 10,000 and 160,000 km^2 in extent, spanning a huge diversity in climate conditions, soil types, groundwater systems, land-use patterns, and social systems. What is perhaps less obvious is the complexity of processes and management actions taking place within these catchments. These catchments provide resources for various needs, including water supply for industry, primary production and consumptive uses, environmental flows for aquatic ecosystems, flood protection, assimilation of greenhouse gases, timber for plantations and water-based recreation. Catchment managers need to balance these various needs when planning strategies that impinge on the water, sediment and solute balances of catchments.

This balancing act hasn't always been successful and we are now dealing with the consequences. Land salinisation, eutrophication of water bodies, and degraded river habitat are just some examples of the legacy we are now struggling to manage.

The CRC for Catchment Hydrology's research and development strategy reflects its belief that;

(i) interventions are required to address most catchment problems, and

(ii) catchment managers need much better modelling tools to properly plan them.

In particular, we argue that few tools are available to forecast the multiple and interacting effects of land management actions at the whole-of-catchment scale.

Our contribution to the problem – the Toolkit

What are we doing to help the situation? Our response has been to focus our efforts on the development of a new predictive capability, the key features of which include:

- An ability to model interacting processes and responses in catchments
- An ability to model these at a range of scales, including the scales appropriate for our focus catchments
- Incorporation of the most up-to-date scientific knowledge in models, tailored to the needs of the catchment management industry
- A significant increase in accessibility to predictive tools, and the training needed to become proficient in their use

This new predictive capability will be embedded in a variety of software products, collectively referred to as the 'Catchment Modelling Toolkit'. Many of you will have heard us talk about the Toolkit in an arm-waving way. After considerable planning we can now be more specific about it.

Our current thinking is that the Toolkit will consist of:

- A library of models that can be applied to various catchment management problems (at a variety of time and space scales), and interlinked with one another
- Guidance on matching models to particular catchment management problems
- A suite of data generation and manipulation tools to support catchment modelling
- A development environment for programmers to write models (and associated documentation) to a specified standard
- A set of standards for data storage and possibly a data base of public-domain environmental data for use in catchment modelling

Much of what sits in the Toolkit will be unified under a common software framework that will encourage reuse of the software by model and tool developers, thus reducing duplication of effort across our industry. Our user surveys have revealed that, to date, this duplication of effort has been significant and very costly. Use of a common framework will also enhance our ability to link together different kinds of models, so that we can achieve that hitherto elusive goal of integrated or holistic catchment scale modelling.

WHERE WE ARE AT

Over the last year we have focused on selecting a modelling framework to suit our long-term model development and delivery needs. We cut a long list of candidates to six for deeper evaluation, and quite recently reduced this to two. For the foreseeable future we will co-develop two systems known as Tarsier and ICMS for complex and simple modelling applications, respectively. We've already built quite a few catchment models and support tools using these frameworks and demonstrated their potential. The South East Queensland Environmental Management Support System (EMSS) is one such example (built using Tarsier). In the coming months we will be addressing the deficiencies of these frameworks, then commencing a program of training aimed at equipping CRC (and affiliated) researchers with the skills needed to develop software in these systems. Researchers in the CRC have also developed many useful models that stand alone outside the Tarsier and ICMS frameworks. These include the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) for improving urban stormwater design and S_PROG for numerical weather prediction. These and other stand alone models will form a vital part of the toolkit.

The disciplinary expertise required to build the various elements of the Toolkit is spread across the CRC, with several modellers and programmers resident in each of the research programs. There are many models and support tools being built by individuals to do discrete things at particular scales. We are now engaged in a process of identifying what we have and how it can be linked together. A CRC workshop will be held in November this year to aid this process. As part of the future (round two) project planning process (commencing soon) we will also identify what key gaps exist in our modelling portfolio. One of the design criteria for each new project will be its contribution to filling those gaps.

A VISION FOR 2006 ... A TOOLKIT ODYSSEY

Some would regard the idea of a Catchment Modelling Toolkit as pretty abstract. Fair enough. It's tough to sell its potential unless you can see something tangible that is doing a particular job. So, for now, let's imagine what the Toolkit might be in a few years time.

Imagine the year 2006, when the CRC finishes its term of funding (and the Toolkit is complete). In one of our focus catchments there is heated debate amongst stakeholders regarding the allocation of water, the quality of what is available and the condition of aquatic habitat in the rivers (In this respect, nothing has changed!). There is a push from certain sectors of government and the community to afforest large tracts of the catchment, but there are questions about the impact that this might have. Even for those signed up to the planned changes, there is confusion about how to implement the afforestation strategy for optimal effect. Here, there is a vital role for the Toolkit in evaluating the merits (and demerits) of the strategy and advising on how to maximise its benefits. Under such a scenario, the Toolkit could conceivably be used in the following ways:

A small modelling task force (say of three people) turns to the CRC Toolkit website and starts an assessment of which data sets and tools are available and needed for their job. An expert system helps them with some of the choices they have to make between different data and modelling options. Once their plan of attack is settled, they begin downloading data (from our focus catchment data base), modelling support tools (from our support tools library) and finally, models (from our model library).

First the data sets

Even today we have some very good national data coverages, but in 2006 these will be better and more comprehensive, with new data coming from international organisations such as NASA. A high resolution digital elevation model (DEM) will be downloaded along with climate, soils and land-use surfaces. Many of these will have been partly derived from high resolution remote-sensing imagery. Our focus catchment database will be a one-stop-shop for virtually all of the task forces modelling needs. By 2006, most Australian resource agencies will have been enlightened by the virtues of providing free access to their databases for land and water management.

Now, the modelling support tools

From the support tool library, **a watershed analyst** (developed by researchers in the CRC's Predicting Catchment Behaviour Research Program) will be selected. Using the DEM as input, this will generate a

CRC PUBLICATIONS LIST

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www.catchment.crc.org.au

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The Centre's products can be ordered through the Centre Office.

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hierarchy of catchment, subcatchments, hillslopes and smaller units, interconnected by a river network, stratified into different orders of stream. A whole set of terrain metrics will also be computed by the watershed analyst, including maps of slope, aspect, curvature, convergence, connectedness to streams, etc. Landscape parameters such as climate, soils and land-use will be linked automatically on this hierarchy. Flow gauging stations (and data associated with them) will be fused on to the river network so that model comparisons against observations can be made. Because the task force will want to predict the probability of a certain outcome in their modelling scenarios, they will use stochastic climate data to drive their simulations. From our model library they will invoke various **climate generation models** (developed by researchers in the Climate Variability Program). These models will produce long-term climate series that faithfully mimic the statistics of the historical rainfall data they use as input. All of the data sets used in this modelling project will have declared measurement errors; an **uncertainty analyst** from the support tool library will keep track of these.

Finally, the models

To begin with, the task force will invoke a **water balance model** aimed at getting the catchment soil moisture distribution and runoff budget right. This will have been co-developed by researchers in Projects 2.3 (Predicting the effects of land-use changes on catchment water yield and stream salinity) and 1.2 (Scaling procedures to support process-based modelling at large scales) and will predict how the changed evaporation characteristics of forests will impact on the water budget. This model will be linked to a **groundwater model** that simulates watertable levels and salt export across the focus catchment – a model developed by researchers in Project 2.6 (Predicting the combined environmental impact of catchment management regimes on dryland salinity). This will reveal the sources of salt input to rivers and predict how salt concentrations in streamflow will change in response to an altered catchment water balance.

Next, a **sediment and nutrient generation model** (developed by researchers in Projects 2.2 – Managing pollutant delivery in dryland upland catchments - and 2.5 – Nitrogen and carbon dynamics in riparian buffer zones) will be linked in, as will a channel geomorphology model developed by the team for Project 2.1 team (Sediment movement, water quality and physical habitat in large river systems). This latter model will simulate how sediment is stored and moved within the river network, revealing long-term dynamics such as sand slugs, and medium-term dynamics such as pool and riffle development.

Related models developed by Program 6 (River Restoration) researchers will then be added; these will link the in-channel dynamics to **floodplain dynamics models** and predict the **aquatic ecological consequences** of channel change and pollutant loading.

These various models will all require different grains of data, some needing fine resolution time series data (say for sediment washoff), others needing only coarse data (say for groundwater dynamics). A **scale manager** (developed by the Project 1.2 team) will process the raw input data feeding sensible aggregations and disaggregations of spatial and temporal data to the various models. The whole set of simulations will be run using different water allocation scenarios, derived using **water allocation and trading models** developed by researchers in Program 3 (Sustainable Water Allocation). Urban areas in the catchment will be modelled using MUSIC and associated tools and data from Program 4 (Urban Stormwater Quality).

As with the input data used in the project, the model will be imperfect. The **uncertainty analyst** will keep track of model errors (as well as data errors) so that users of the model can assign a level of confidence to the predictions.

CONCLUDING

This vision would have us predicting the cumulative effects of a particular land-use change against the backdrop of a variable climate and alternative water allocation options. Impacts would be forecast at a range of spatial and temporal scales for a variety of indicators, including flow regime, water quality, channel condition and aquatic ecologic response. We could conceive of others also, including social and economic impacts on communities; these might be added in at a later date. We actually aren't such a long way from this vision, as several of the tools and models referred to above are ready or in an advanced state of development. What is lacking is a framework to interlink them, though we are close to that too.

In conclusion, we have an ambitious modelling objective and assembled talented teams across our CRC to contribute to the different parts. Integrating that talent presents huge challenges, but will yield huge benefits if we succeed.

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THE YARRA FOCUS CATCHMENT

by IAN RUTHERFURD and GRAHAM ROONEY

CATCHMENT DESCRIPTION

The Yarra River rises in the Great Dividing Range and flows 245 kilometres to reach Port Phillip Bay at Newport. Its catchment area is more than 4,000 square kilometres, of which about 1500 km^2, particularly in the lower reaches, is urbanised. More than 1.5 million people live within its boundaries.

The Yarra, and other tributaries to Port Phillip Bay, are managed by Melbourne Water and the Department of Natural Resources and Environment with the exception of the smallest tributaries that are managed by local councils. These stream systems comprise over 5,000 km of piped, channelised, rural and natural channels.

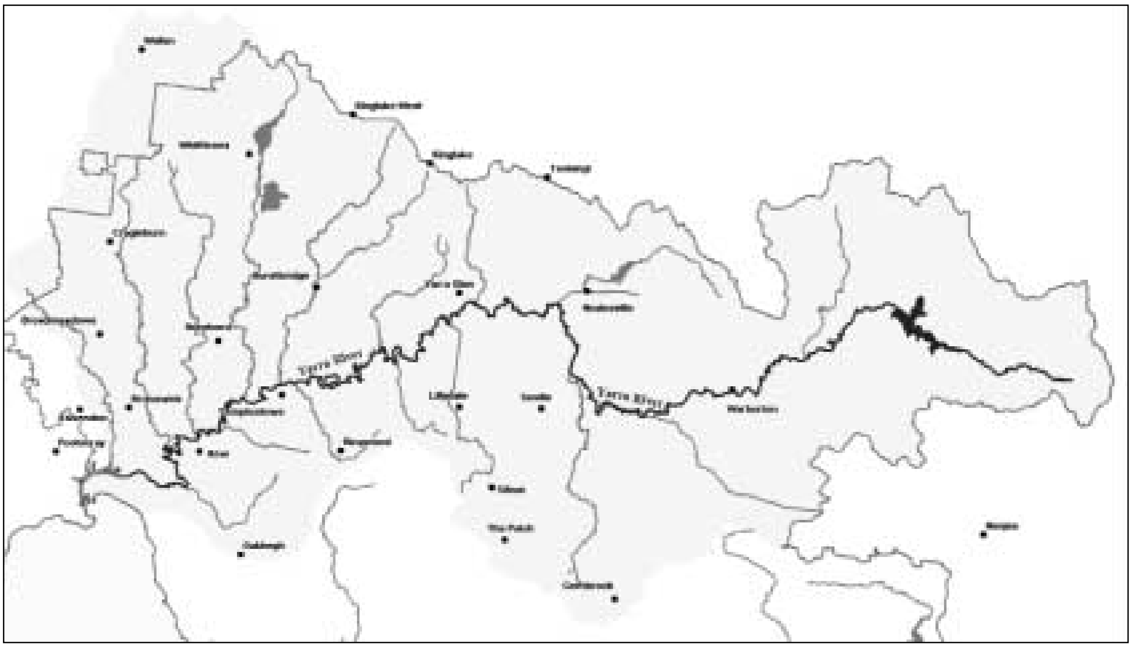
CATCHMENT ISSUES

Melbourne Water has benefited from the CRC's research in its initial round (1992-1999), both in understanding catchment-vegetation influences on water yield to reservoirs, and the nature of diffuse-source contributions to poor reservoir water quality. Attention is now turning to the condition of the streams in the Yarra system themselves.

Streams in the Yarra catchment range in condition from remarkably pristine (in the closed water supply catchments) to concrete drains. It is estimated that the 1,500 km^2 of urban area will grow to 3,100 km^2 by 2020. Over the years, Melbourne Water and predecessor organisations have reduced the flood hazard in urban parts of the Yarra, and its surrounding catchments (especially the Dandenong Creek system to the east), as well as progressively controlling stream erosion. However, this management has come at the expense of the ecological condition of the streams and Port Phillip Bay. Some 40% of waterways are rated as 'poor' or 'very poor' in terms of habitat structure, and loss of in-stream habitat is regarded as a serious problem. Port Phillip Bay has an excess of nitrogen, and catchment load reductions have been recommended in order to protect the bay's ecosystem into the future.

There is increasing pressure on river flows from diversions and off-stream storage – with 1,319 licences and an allowed annual volume of 34,770 ML taken from the river. Water is also diverted into Sugarloaf reservoir from the Yering Gorge site – for supply of treated drinking water. These extractions have significant impacts on the Yarra River.

The focus of management in the Yarra Catchment is now turning to stream health and stream rehabilitation. The health of organisms in streams and the Bay - including fish, invertebrates, and platypus – is seen to be the ultimate measure of whether waterway management programs are working. Melbourne Water spends about $6 million annually on waterway 'rehabilitation works' and a further $5.2 million on urban stormwater quality improvement measures.



Yarra Catchment

NEW CRC REPORT

THE CALCULATION OF STREAMFLOW FROM MEASUREMENTS OF STAGE

by
John Fenton and
Bob Keller

Report 01/6

This report is the key output from Project FL3, 'Hydraulic Derivation of Stream Rating Curves', part of the initial CRC's Flood Hydrology Program.

The main aims of the Project were to:

- To improve current methods of converting measured water levels to flow rates, especially for high flows; and
- Thereby to improve the reliability of flood estimates.

The report is divided into two main parts. The first part is a more descriptive presentation that is intended to be able to be read without it being necessary to refer to the second part, which consists of appendices providing technical details, as well as a presentation of the hydraulics of river flow.

Copies available from the Centre Office for $27.50

Based on these catchment issues, the following are identified as the major research requirements for the streams of the Port Phillip Bay catchments:

- Stormwater quality. Melbourne is rapidly spreading, and Melbourne Water's aim is to at least maintain water quality in streams. Earlier research by the CRC targeted sources of gross pollutants, and poor stormwater quality. Research is now turning to approaches to managing nitrogen loads in stormwater runoff in tributaries to the Bay. How, for example, should Melbourne Water manage stormwater in both 'green-field', and new urban 'in-fill', developments?
- Improved habitat and hydraulic environments in streams. Improving the health of Melbourne's streams is a priority. This involves determining methods and approaches for reinstating more natural stream habitats, designing fishways, adding large woody debris, and restoring altered flows.
- Planning approaches to river restoration. Integrating rehabilitation projects is difficult and novel; managers need tools to help plan and execute them. One of the key tasks here is to identify targets for management (eg. target pollution or velocity levels), and to set priorities for management actions.
- Water Sensitive Urban Design - the facilitation of integrated stormwater quality improvement measures into urban development.

HOW IS THE CRC TACKLING THESE ISSUES?

Several projects in the CRC are targeted directly at the Melbourne Water catchments.

Stormwater quality
The CRC's Urban Stormwater Quality Program aims to improve urban streams, with the major focus being the Yarra and Brisbane River catchments. The research also covers stormwater pollution sources, pathways and impacts, with the intention of developing best management practice guidelines. The Program is developing targets for stormwater quality, assessing treatment options, trialling treatment options, and finally developing best management practices that are packaged in a decision support system. A major aspect of this work is to develop a stochastic, or risk-based approach to stormwater management for the protection of aquatic ecosystems.

Planning approaches
Many processes, apart from water quality itself, damage the health of urban streams. Over the next 20 years, Melbourne Water will make a major investment in improving stream health, including habitat and hydraulics. Project 6.2 of the River Restoration Program (Optimising urban stream rehabilitation planning and execution) aims to determine whether it will be possible to achieve environmental targets over an urban catchment. A modelling approach will assess, for example, how much it would cost to achieve desirable

A cut-off on the Yarra River at Yarra Grange near Healesville flow velocities, water quality peaks, or flow durations. This work is being done in the Dandenong Creek catchment (adjacent to the Yarra, but still applicable).

Understanding habitat and hydraulic environments in urban streams
Managers must be confident that their efforts to improve the physical and water quality conditions of urban streams will lead to some improvement in biological condition. To this end, several projects (jointly with the Cooperative Research Centre for Freshwater Ecology - CRCFE) investigate the relationship between urban hydrology and stream health. Some examples are:

- The "Urbanisation and the ecological function of streams". This work is developing empirical relationships between catchment-scale impacts of urbanisation (imperviousness and drainage connectivity) and instream processes, including nutrient processing, macroinvertebrate and algal community composition. The models developed from this project will be linked to those in the Urban Stormwater Quality Research Program's Model for Urban Stormwater Improvement Conceptualisation (MUSIC). This software will provide a more holistic decision support system for urban stormwater management, as mentioned above.
- Best practice guidelines for stormwater in the Yarra catchment are being supported by fundamental research into the sources of stormwater pollution, and its treatment. A PhD project at The University of Melbourne is examining the characteristics of urban stormwater, and in particular, the association between nutrients, contaminants and sediment particle size. This work will allow stormwater treatment measures to be better designed to remove key stormwater pollutants.

Wetlands
Research into the role of wetlands in removing stormwater pollutants is being undertaken at sites in Melbourne, including the Ruffeys (Doncaster) and Hallam Wetlands. In the latter study, the impact of vegetation on removal of suspended solids is being examined. Field experiments aimed at testing the performance of Water Sensitive Urban Design technologies (e.g. vegetated swales, and bioretention systems) are being undertaken at Lynbrook Estate, a new residential estate in Lyndhurst.

Restoring Stream Health
A major experiment that will attempt to isolate the relative role of stormwater, high flow velocities, and in-stream habitat, on stream health (using macroinvertebrates and diatoms as measured) is being prepared as part of the River Restoration Program. This collaborative experiment with CRCFE will retrofit existing flood detention basins as a way of returning some aspects of natural flood hydraulics to urban streams.
The CRC is also involved in advising Melbourne Water on the reinstatement of large woody debris in the Little Yarra River.

Other Projects
Outputs from other CRC for Catchment Hydrology projects also promise to have strong application in the Yarra catchment. The EMSS model, from Program 1 (Predicting Catchment Behaviour), is likely to be trialled in the catchment, providing catchment scale predictions of water quality. Similarly, the stochastic climate models of the Climate Variability Program will be incorporated into MUSIC and the Dandenong Creek models described above.

WHAT HAVE WE LEARNED TO DATE?

Here are some of the outputs of the research so far:

- Development of a pilot version of the MUSIC software that allows managers to design optimum stormwater treatment trains. This software is now being trialled by Melbourne Water, with a wider release expected in autumn next year.
- Development of the Lynbrook Estate alternative drainage scheme east of Melbourne. This is a best-practice demonstration site using grass swales, bioretention, systems and other vegetation treatments.
- Basic research (numerical modelling) into the effect of vegetation on hydraulic efficiency in artificial wetlands. This work has shown the optimal arrangement of vegetation.

PARTICIPATION OF STAKEHOLDERS

The major stakeholder groups in the Yarra catchment are Melbourne Water, the Department of Natural Resources and Environment, Victoria, Monash University, The University of Melbourne, and the Cooperative Research Centre for Freshwater Ecology. Several staff from Melbourne Water have been seconded to the CRC projects in some capacity.

NEW TECHNICAL REPORT

WATER SENSITIVE URBAN DESIGN IN THE AUSTRALIAN CONTEXT - CONFERENCE SYNTHESIS

by
Sara Lloyd

Report 01/7

In August 2000 a conference was held in Melbourne to highlight and explore the opportunities and impediments to the adoption of Water Sensitive Urban Design (WSUD). WSUD is the term used to describe a new approach to urban planning and design that offers sustainable solutions for the integration of land development and the natural water cycle.

This report collates and summarises the key issues raised at the conference, focusing on the current barriers to the widespread adoption of WSUD principles and offers possible solutions to help overcome both short term and long term issues.

Please note that conference attendees will be sent a complimentary copy

Copies available through the Centre Office for $27.50.

For further information contact the Centre Office on 03 9905 2704

Projects are being carried-out jointly with the CRC for Freshwater Ecology, so there are further opportunities to integrate the research. In addition, a Yarra Forum has been organised by Peter Cottingham (CRCFE) and Melbourne Water's Graham Rooney (the Yarra Focus Catchment Coordinator), in which researchers and managers come together to reveal findings and gaps in our knowledge. There have been three meetings of this interdisciplinary group so far.

TANGIBLE BENEFITS

The most immediate benefits that have developed from the CRC program to date in the Yarra catchment are a result of the Urban Stormwater Quality Research Program. The development of the MUSIC software is having a significant influence on the management of urban stormwater issues throughout the Melbourne metropolitan area, including the Yarra catchment. Several training sessions have already been held with Melbourne Water staff.

MUSIC forms part of the CRC's modelling toolkit (Program 1 – Predicting Catchment Behaviour), which will provide a range of models to suit a range of applications in catchment management. Melbourne Water is presently using the 'pilot-version' of MUSIC to develop stormwater management strategies and infrastructure programs for a number of 'greenfields' catchments, along with a number of 're-development' areas. In all of these cases, MUSIC is being used to formulate the most cost-effective way to meet water quality targets, and to identify areas where there may be a 'shortfall' in meeting the target. Melbourne Water may then consider a form of 'stormwater quality trading', where achievements in excess of water quality standards in one sub-catchment may be able to offset shortfalls in another. Whilst this concept is at its very formative stages, MUSIC is helping to provide an objective decision-making framework for such analysis. Ultimately, when combined with the research into new technologies for Water Sensitive Urban Design (WSUD), the application of tools such as MUSIC and EMSS across the entire Yarra catchment will help to optimise urban water quality management.

The innovative design of alternative stormwater drainage scheme at Lynbrook Estate, east of Melbourne, has generated tremendous interest with developers and managers alike – particularly since this work won the 2001 CRC Association Award for Excellence in Technology Transfer. There is ample evidence that this project is encouraging other councils to adopt WSUD to better manage stormwater runoff.

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THE GOULBURN BROKEN FOCUS CATCHMENT

by TOM MCMAHON and PAT FEEHAN

CATCHMENT DESCRIPTION

The Goulburn Broken (G-B) catchments cover 24,000 km^2 in northern Victoria. With a population of 250,000 people, the region generates about $1.5 billion worth of food products annually. Salinity and nutrient management are key issues, as are afforestation and water allocation under the tradeable water-rights system.

The two key impoundments Lake Eildon and Goulburn Weir have modified streamflows along the Goulburn River. Eildon has a capacity of 3490 GL and supplies more than half of the water used in the Shepparton irrigation area. The Goulburn Weir, near Nagambie, diverts water east and west for irrigation.

CATCHMENT ISSUES

There are five main catchment issues in the G-B of concern to catchment managers, irrigators and the local community. These are water quantity, water quality, nutrients, river restoration and water allocation.

Water Quantity

In terms of water quantity, there is concern about the potential impacts on water yield of large scale afforestation programs. The potential impacts of climate change are another concern.

Secondly, performance of the water supply system in terms of reliability and predictability associated with managing the channel system is of great importance to water supply authorities and their customers. Associated with this is the large volume of water lost by seepage in the delivery system.

Water trading allows water to move between areas. Understanding the impacts of trade on the supply and delivery system, and ensuring the water market is maximising the economic benefits of water use and minimising disbenefits, are very important issues to the farming and local communities.

The final water quantity issue relates to the impact that new developments and enterprises away from

Goulburn Broken Catchment

NEW WATER ALLOCATION RESEARCH REPORT

IRRIGATOR AND COMMUNITY ATTITUDES TO WATER ALLOCATION AND TRADING: A COMPARATIVE STUDY OF THE GOULBURN BROKEN AND FITZROY CATCHMENTS

by

John Tisdell
John Ward
Tony Grudzinski

Report 01/5

This new technical report details the findings of a comparative study of attitudes and opinions on water reform, allocation and trading between irrigators and community members in the Goulburn Broken (Vic) and Fitzroy (Qld) catchments.

The analysis provides insights to general opinion, and expectation of and blockages to, water reform in two eastern Australia catchments.

All of our publications can be ordered through the Centre Office.

traditional irrigation areas will have on downstream users and the environment.

Water Quality

The second major issue relates to water quality. Currently, 45% of the Shepparton Irrigation Region is underlain by shallow watertables; this is expected to rise to 60% by 2020 if nothing is done. In this scenario, the current annual agricultural loss of $30-47 million would reach $490 million.

In the dryland region some 4500 ha is heavily salinised. This will ultimately increase to 38,000 ha in 50 years if nothing is done.

Further, the catchment exports an average of 180,000 tonnes of salt from dryland catchments to either the River Murray or the irrigation region. This is expected to increase to 250,000 tonnes in 50 years if nothing is done.

Nutrients

Nutrients are the third major concern in the region. In the Murray-Darling Basin the G-B catchment is Victoria's highest priority for nutrient reduction; blue-green algal blooms occur frequently. An average of 360 tonnes of phosphorus is exported from the catchment annually. Major nutrient sources include irrigation drainage, dryland and sewage treatment plants.

River Restoration

River restoration is another major concern to the catchment communities. Some 45% of the waterways are in very poor, poor, or moderate environmental condition. The Regional Catchment Strategy aims to improve the condition of 3000 km of streams to good or excellent condition over the next 30 years, while maintaining the environmental condition of streams currently rated good or excellent. Water quality in streams in the catchment progressively deteriorates downstream.

Water Allocation

Finally, water allocation, where the issues deal on the one hand with a finite share of water for consumptive uses in the G-B catchments, and with environmental flows on the other. The Murray-Darling Basin cap has placed further constraints on the level of diversion from the stream system. Streamflow Management Plans are being developed to address water diversion and environmental flow issues.

HOW IS THE CRC TACKLING THESE ISSUES?

To address the issue of land-use change and its effects through afforestation by eucalypts and pines, the CRC brings a whole-of-catchment view to water balance calculations. Computer models with a GIS capability have been developed to assess the effect of land-use changes. Water balances at the catchment level benefit from the recent completion of the evapotranspiration maps for Australia produced by the CRC in collaboration with the Bureau of Meteorology.

The CRC is also taking advantage of recent work carried out within the National Land and Water Resources Audit to address the following questions:

- Where in the catchment are sediments and nutrients derived and where do they impact?
- Where will remediation efforts be best targetted?
- What are the future trajectories of adjustment to change?
- What is the effect of land-use change on catchment yield?
- How do we represent management of pollutant sources at the catchment scale?

As part of addressing the water allocation issues, a questionnaire survey was conducted in the Goulburn Broken region covering 2000 irrigators and the community. This gathered information on the nature of water markets, and has already provided input to water policy development in the region to enhance water trading in the G-B catchment.

In collaboration with the Goulburn Broken Catchment Management Authority and the CRC for Freshwater Ecology, 18 sites have been established in the Granite Creeks area to explore the physical and biological response of sand-slugged streams to respond to habitat restoration measures.

WHAT HAVE WE LEARNED TO DATE?

Water Quantity

Initial modelling suggests that large scale plantations in the Lake Eildon catchment would have a significant impact on inflows to the reservoir. For example, if 100% of the area suitable for blue gums above Lake Eildon becomes plantation (90,000 ha), mean annual inflow would be reduced by about 7% (or about 130 GL per year).

Water Allocation

Analysis of the responses of the survey of irrigators and the community has indicated several clear trends in understanding the impacts of COAG reforms and water trading activities. These include:

- Irrigators consider ensuring a fair and just distribution of water as most important.
- Respondents are generally supportive of water reform, but the community at large has been poorly informed during the reform process.
- There is overall agreement that the nexus, or link, between land and water should be broken and water rights traded as chattels separate from land.
- Irrigators overall believe that water entitlements will be more secure and have higher reliability following the reform process.
- The notion that a farmer's entitlement would no longer be an inherent asset in farming is not accepted by survey respondents.

Climate Variability

Preliminary results from the CRC's Program 5 – Climate Variability – suggest there is potential to utilise the outputs from the Bureau of Meteorology's Numerical Prediction models and the radar imagery analysis. For example, the application of this new technology could include improvements in irrigation demand forecasting and scheduling, better flood forecasts, more accurate estimates of low flows, and direct prediction of catchment rainfall for managing Lake Eildon. These potential applications are the subject of a workshop to be held at Tatura in October, 2001.

A by-product of rainfall analysis in the Climate Variability Program showed that the recent drought, which has impacted significantly on the yield of Melbourne's water supply catchments, has been less severe in the G-B catchments. Such analyses help catchment and water managers to assess the risks involved in water allocation operations.

PARTICIPATION OF STAKEHOLDERS

The initial participation of stakeholders in the research development process occurred during the CRC's Technical Advisory Group meetings when the research topics were proposed. Since then, the approach of engaging stakeholders through regular workshops, seminars and field visits has continued as projects have developed across the six research programs. The focus of this communication has been through the Focus Catchment Coordinator.

As an initiative in the G-B to ensure that the research results are translated into "on-the-ground" responses, key contact persons for each project have been appointed in Goulburn-Murray Water. Each of these is someone who, as part of their normal work activities, is likely to have some influence, or responsibility, to implement project research outcomes.

Specific workshops, and more general seminars, have been conducted in the catchments to provide initial results from the research programs. These also engaged the stakeholders directly in developing a communication and adoption strategy.

Seminars have been held to discuss the results from the extensive questionnaire survey dealing with the irrigator and community attitudes to water allocation and trading.

TANGIBLE BENEFITS

The outcomes of the CRC's research programs are relevant to a wide range of resource managers in the G-B. These include Goulburn-Murray Water (rural water authority) and its customers, the Goulburn Broken Catchment Management Authority, and other government agencies such as the Department of Natural Resources and Environment. Indirectly the research outcomes will be relevant to landcare groups and individual landholders in dryland and irrigation areas.

Much of the benefit of the CRC activity in the G-B catchment will be realised through on-ground works, for example, the aquatic habitat restoration in Granite Creeks, or from the development of water trading guidelines and policy following understanding of community and irrigator attitudes to COAG reform and water trading.

Many of the research tools and outcomes developed or tested within the G-B focus catchment will be in a form that can be applied to catchments of other north and westward flowing rivers in the Murray Basin. In addition to those incorporated in the CRC's Modelling Toolkit, these tools and outcomes would include:

- water yield models of land-use change,
- techniques relating to estimation of sediment and nutrient sources, transport and fate,
- water trading policies derived from consumer surveys and model simulations
- enhancements to the Bureau of Meteorology modelling capability, and
- techniques to explore the physical and biological response of sand-slugged streams to habitat restoration.

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ENVIRONMENTAL FLOWS SEMINAR

ENVIRONMENTAL FLOWS - THEORY, PRACTICE AND MANAGEMENT

Monday, 19 November 2001
8.30am - 4.30pm

The Rainforest Room
Melbourne Zoo
Elliott Avenue
Parkville, Victoria

This Seminar will be a valuable forum information sharing between scientists, managers and practitioners. It will provide participants with a framework that they can start to think about the impacts of flow regime changes.

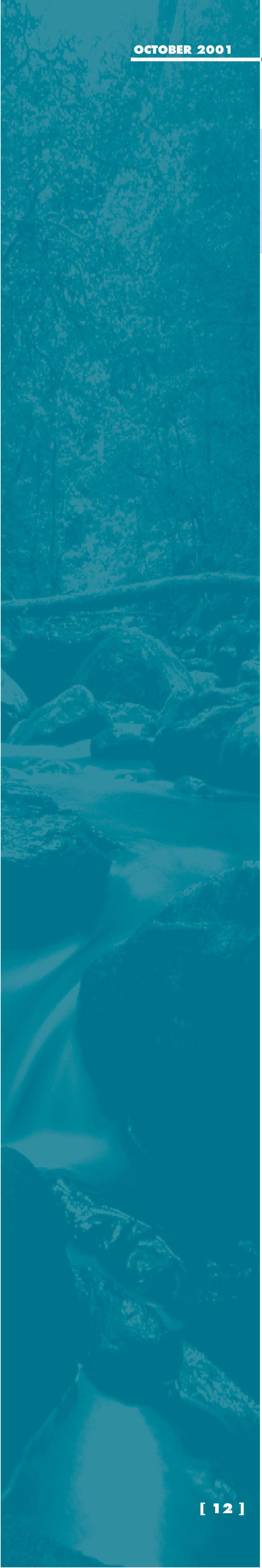
Cost:
$100 Registration Fee
$80 RBMS and IEAust Members
$70 Students and Community Groups

Registration and enquiries:
For registration form/enquiries please contact
Craig Donovan, IE Aust.
Tel: 03 9321 1721
Fax: 03 9326 6515

For further information, please contact Mike Stewardson (non-registration enquiries) on 03 8344 7733.

Supported by Goulburn-Murray Water, Melbourne Water and Thiess Hydrographic Services.

See the flyer with this Catchword



THE MURRUMBIDGEE CATCHMENT

by PETER HAIRSINE and CAROLYN YOUNG

CATCHMENT FEATURES

The Murrumbidgee catchment is a major sub-catchment of the Murray-Darling Basin and covers an area of 73,400 km^2. Extending from the alpine areas and Southern Tablelands in the east to the Southwest Slopes and onto the Riverine Plains in the west, the catchment is highly variable in terms of physical characteristics.

The Murrumbidgee River flows for 1,600km and plays host to 14 major dams, 8 large weirs. The Snowy Mountains Hydro Electric Scheme assists with regulating water flow and supplying some 10,000km of irrigation channels.

Land-use varies from sheep and cattle grazing, conservation reserves and expansion of residential areas in the upper catchment, to irrigated agriculture, horticulture, dryland cropping and grazing, and forestry in the mid and lower areas of the catchment. The Murrumbidgee catchment is one of the most densely populated regions in rural Australia - it has over 520,000 people, including the ACT, with a growth rate of 1.5% pa.

THE COMMUNITY WANTS RESEARCH OUTCOMES – SOME INTEGRATED, SOME NOT

The Murrumbidgee Catchment Management Board is currently hosting public meetings to get public input and feedback for the Catchment Management Targets set up as part of the catchment management plan (see http://murrumbidgee-catchment.org.au/frame/targets.htm).

Land managers, including property and farm owners, managers, farming contractors, rural consultants and natural resources agency staff, are true integrators; the discussion in the public forums demonstrates this time and time again. Comments and questions generally deal with the link between different components of the land management and catchment systems. In terms of integration, researchers continue to have much to learn from land managers in terms of integration.

Among the issues raised – to which the CRC for Catchment Hydrology can contribute – were:

- Quantifying onsite and offsite benefits of land-use change.
- Providing a better understanding of nutrient loads from point sources compared to diffuse sources in the Murrumbidgee Catchment.
- Estimating the time lags between management action and response to that action, in particular regards to salt, suspended solids, and nutrients in rivers.
- Where to locate vegetation to prevent and manage discharge from salt yielding groundwater systems.
- The impacts of plantations on streamflow yield.
- Riparian vegetation - which streams should be given priority to maximise sediment control and biodiversity?
- The location and movement of sand slugs in the Murrumbidgee Catchment rivers, and habitat rehabilitation options.
- Evaluating management scenarios and the inevitable trade-offs that will be needed (eg. reducing salt concentration versus increasing biodiversity).
- Guidance on the design and placement of off-stream watering and/or fencing.
- Assistance with calculating environmental credits in regard to the planned trading of environment services.
- The influence of climate change and climate variability on these issues

However, most of the questions in the forums relate to on-ground action, such as:

- What will be the cost sharing arrangements for revegetation that involve benefits for the river?
- How can we justify fencing-out our streams to reduce nutrients getting into the river when Canberra continues to put huge amounts of sewage in the Murrumbidgee?
- Where should revegetation occur to stop salinity?
- How do stream targets relate to what I do on my farm?
- Doesn't planting land back to trees dry up the river?
- Why fence-out streams that only flow one month a year?
- Are the management targets compulsory?

A considered technical response to these questions can only be made if we think about the Murrumbidgee as a system of connected components. Isolated single-issue responses may be useful in some instances, but consideration of different single issues will frequently result in conflicting land management recommendations. For instance, salinity considerations may lead to recommendations about restoring vegetation on the upper and mid-slopes of the landscape. Controlling sediment movement to the stream will result in recommendations to restore just the riparian vegetation. Land and water managers seek integrated advice that they can balance with factors not often considered by specialists.

In the following discussion, we attempt to give a picture of how the research of the CRC relates to the Murrumbidgee Catchments' real world problems in an integrated way. We recognise that our integration is in its early stages and in some places is greatly lacking. However the CRC environment has resulted in some significant steps along the path to integration in the catchment. The headings used below reflect our thinking on the cluster or threads of integration issues.

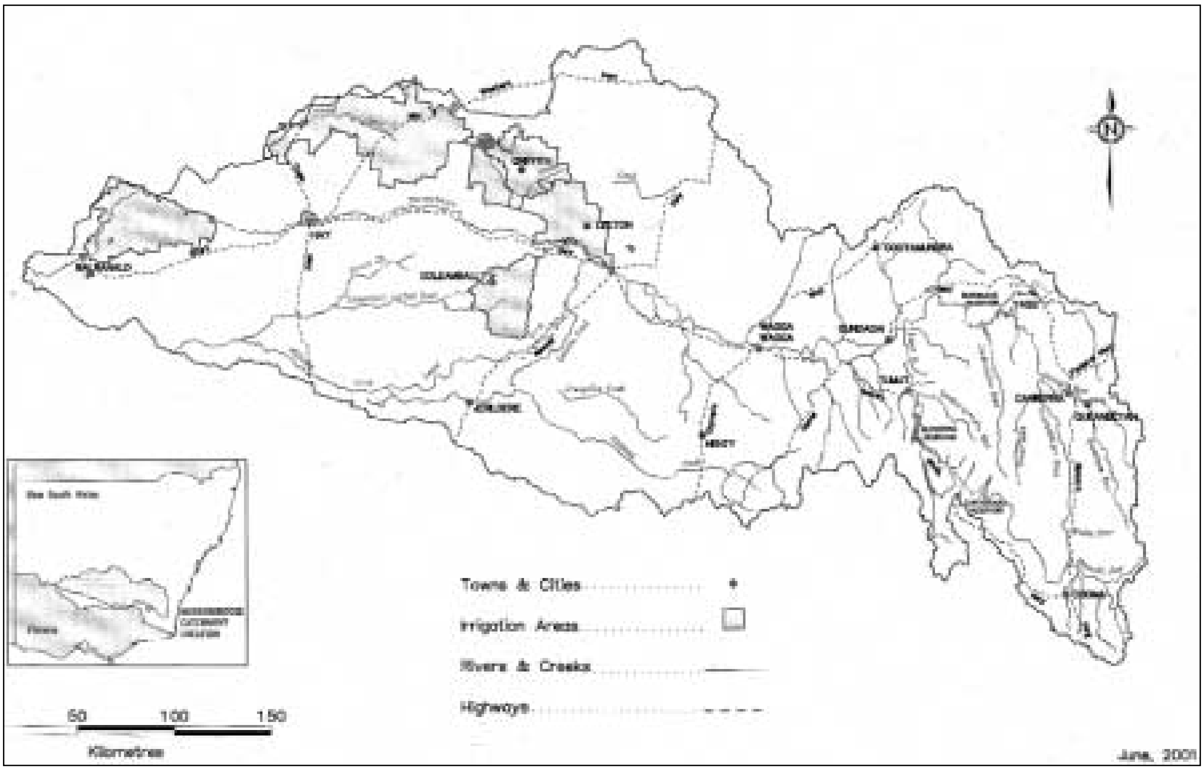
RAINFALL TO STREAMFLOW

Fundamental to catchment hydrology is the accounting of water as it moves through a catchment. Rainfall is distributed between a number of pathways through which it flows or is recycled. Hydrology as a discipline has given us much insight into these processes. Several of the CRC projects will give us refinements for the Murrumbidgee. Let's start with the rainfall.

We currently have quite sophisticated predictions of rainfall in the short term, medium term and long term provided by the Bureau of Meteorology. CRC research is contributing to improvements in medium term forecasts (up to one week in advance) through its work on the land surface scheme of the numerical weather prediction model (part of the Climate Variability Program). The research aims to provide a vastly improved way of including the effect of soil moisture on rainfall occurrence across the catchment. Monitoring sites, which continuously monitor soil moisture, are being established across the Murrumbidgee catchment. These are supplemented with periods of intense spatial monitoring so that the space and time variability can be described. (See Francis Chiew, Andrew Western and Harald Ritcher's article in the July 2001 edition of *Catchword* for more details. http://www.catchment.crc.org.au/products/catchword/2001/catch96.pdf)

The monitoring and modelling of soil moisture at a catchment scale provides several important links across our research activities. As well as possibly being useful in weather prediction, soil moisture is an important consideration for those of the CRC concerned with predicting stream flow and pollutant transport.

Lu Zhang and his team at CSIRO Land and Water in Canberra have developed remarkably robust relationships between streamflow and rainfall for large catchments. This so-called "top down" approach is most useful in predicting the effect of land-use change



Murrumbidgee Catchment

NEW TECHNICAL REPORT

IMPLEMENTATION OF A MEAN ANNUAL WATER BALANCE MODEL WITHIN A GIS FRAMEWORK AND APPLICATION TO THE MURRAY-DARLING BASIN

by

Andrew Bradford
Lu Zhang and
Peter Hairsine

Report 01/8

The report describes the implementation of a simple water balance model in a GIS (Geographic Information System) framework for assessing average annual streamflows (water yield) under different land-use scenarios in the Murray-Darling Basin. The model requires only catchment percentage forest cover and mean annual rainfall. The report describes the water balance model, its input data and the process required to prepare those data.

Copies available through the Centre Office for $27.50.

on stream flow, because of its demonstrated portability between catchments. The group have demonstrated to the Murrumbidgee Unregulated Streams Management Committee, and recently to regional Department of Land and Water Conservation (DLWC) staff, the ability to predict the annual average streamflow for a wide range of catchments including the major sub-catchments of the Upper and Middle Murrumbidgee. The proportions of a catchment under perennial, deep-rooted vegetation (including trees) and those under crops were used in the work. Rob Vertessy and Yves Bessard provided the first of this analysis specific to the Murrumbidgee[1]. (See the article by Andrew Bradford and Lu Zhang in the May 2001 edition of *Catchword* for details. http://www.catchment.crc.org.au/products/catchword/2001/catch94.pdf)

With more investigation, these developments offer sound predictions of streamflow from year to year and possibly month to month. The key to this development is a description of water storage in the soils of the landscape. Remember these are very large catchments – hundreds to thousands of square kilometres. The CRC is approaching the description and measurement of storage in a range of ways. As well as the measurements described above, Neil McKenzie and John Gallant are using terrain analysis to describe the expected pattern of soil moisture under a range of rainfall scenarios. The combined research is expected to produce predictions of soil moisture storage for very large parts of landscape. These results can be used in both rainfall and streamflow predictions.

The tools mentioned above have a vital role in managing surface water in the Murrumbidgee catchment. A map of land-use in the Murrumbidgee catchment will look very different in 2020 compared to how it looks today. Various forces are driving these changes, including a rapid expansion of the important plantation forestry industry, the diversification of agriculture, the change in the age structure of land managers, and the community-driven move to revegetation. Importantly, these changes are certain to occur in a non-uniform manner across the catchment. The majority of the plantation developments will occur rapidly in the wetter parts of the catchment (mean annual rainfall approximately greater than 800 millimetres) where growth rates are most likely to be commercially competitive. Community-driven revegetation will be much slower, limited by farm margins and external investment. These changes will largely occur in the drier parts of the catchment, currently the grazing and wheat/sheep belts.

Lu Zhang and his team, with major support from the Murray-Darling Basin Commission, will provide a water yield model that considers the location and timing pattern of these changes. The model will enable the user to predict the streamflows for water allocation planning, and it will assist in the description of salt and other pollutants in streams. The water quality in the wetter parts of the catchment is very high, and it provides a dilution flow for the low quality water which flows from the salt effected, highly-disturbed lowlands. Already this work has provided a GIS tool[2] for predicting mean annual streamflow changes for different land-use scenarios.

A further important link to streamflow is the water available for the irrigation industry in the lower Murrumbidgee catchment. Streamflow forecasts can now be fed into models of water allocation. Our ability to do this is now limited by the time step of current forecasts, but this will improve in the coming two years. Meanwhile, John Tisdell from Griffith University is making good progress in understanding the current irrigation water market. John's work includes the Murrumbidgee focus catchment and he recently gave a seminar to the regional staff of NSW DLWC concerning the community's attitudes to water reform, including water trading.

LINKING GROUND WATER AND SURFACE WATER – SALT UNDER AND ACROSS THE CATCHMENT

An enormous amount of salt has naturally accumulated under the drier parts of the Murrumbidgee catchment. This salt is a problem when it is mobilised and delivered at above natural rates to the surface soils, fresh aquifers and rivers.

The CRC is seeking to better understand the movement of salt through the Murrumbidgee using the combined resources of CSIRO and the Department of Land and Water Conservation, NSW. We are fortunate to have alliances with other major initiatives in the salinity research including the NSW Salinity Strategy, Land and Water Australia's National Dryland Salinity Program, and the Catchment Categorisation for Dryland Salinity Project. Members of this alliance recently gave seminars on research into salinity issues to Murrumbidgee region agency staff.

The consideration of the changes to the groundwater systems as a result of native vegetation clearing are vital to answering a number of key questions:

- Where is revegetation best sited to achieve changes in soil and river salinity?

- What are the time lags between changes to vegetation and the response on land and in rivers?
- What is the extent of revegetation required to stabilise or reverse salinity problems?
- Which parts of the catchment will inevitably become saline, and which parts are suitable only for engineering solutions such as groundwater pumping?

The CRC alone does not have the resources to answer all of these questions. However the alliances mentioned above, and building on previous work in the CRC Parties, are moving us collectively to the answers.

The collaboration between the surface flow specialists, including Lu Zhang's team and the groundwater groups including Mirko Stauffacher (CSIRO) and Narendra Tuteja (NSW DLWC) is enabling, for the first time, a whole-of-catchment approach to salt flows. The groundwater groups bring two important models to the collaboration CATSALT, the NSW DLWC salt balance model, and Flowtube, the CSIRO groundwater flow model.

The question on time lags is being specifically addressed by Mat Gilfedder, Warwick Dawes, Glen Walker and their colleagues at CSIRO Land and Water. While we have understood for some time how groundwater responds to changes in recharge from the surface, this group has developed an approach which enables consideration of all groundwater systems across the catchment, including those whose characterisation is still rudimentary. This very recent development will enable an explicit estimate of the delays in response (10 to 200 years) associated with reducing recharge with revegetation. These time delays are a crucial part of on-the-ground decision making.

SOIL, SEDIMENT, STREAMBANKS AND STREAM HABITAT

The Murrumbidgee is a moderately turbid river carrying large loads of nutrients. For instance, Jon Olley's team at CSIRO estimate that on average some 600 tonnes of phosphorus pass Wagga Wagga each year. Greater than 85 percent of this comes from diffuse rural sources.

Over the last twenty years there has been much research on the source of these sediment and nutrients. This research was demonstrated and consolidated at Murrumbidgee 2000, a forum held in July 2000 to develop a state of knowledge on sediment and nutrients in the Murrumbidgee. Researchers at CSIRO including Bob Wasson (now ANU), Peter Wallbrink and Jon Olley have established that much of the sediment and associated nutrients in the river is derived from gully and streambank erosion, with major ramifications for the priorities for source management. The catchment groups have taken up this finding with the Natural Heritage Trust-funded Bidgee Banks project which has attracted more than $1 million in funding.

The CRC contribution to this area is considerable. CSIRO, The University of Melbourne and NSW Land and Water Conservation have formed a team to investigate the movement of sediment in stream networks and the consequences for the stream habitat. The two focus catchments for this project are the Murrumbidgee and the Goulburn Broken.
(See http://www.catchment.crc.org.au/programs/projects/p2_1.htm).

A key link for this team is the National Land And Water Resources Audit (NLWRA) work concerning sediment movement and nutrient movement through all of Australia's major streams and rivers. Ian Prosser and Bill Young of CSIRO were the main drivers of these impressive products developed during the audit (available soon at http://www.nlwra.gov.au/full/20_products/products.html). These products, which were outlined by Ian Prosser in September 2001 to Murrumbidgee Region DLWC staff, include the state of art assessment of the source and delivery of sediments and nutrients through the entire Murrumbidgee network. Ian and Bill are also CRC project members. The CRC for Catchment Hydrology project is building on the audit products by providing more detailed validation and use of data for the Murrumbidgee.

Some knowledge gaps identified in the audit are also being addressed, including the sediment and nutrient delivery from hillslope to stream
(see http://www.catchment.crc.org.au/programs/projects/ p2_2.htm).

Both coarse and fine sediment are being considered, so that the team are now capable of predicting the fate of sediment including floodplain deposition, accumulation in reservoirs, and the formation of large masses of sand and gravel (called sand slugs) in stream beds. The sediment budgets described above are key inputs to our consideration of the stream restoration. For example, streams that are threatened by sand slugs require different rehabilitation strategies to those that are not. The CRC's River Restoration Program is actively involved in this research. Predicting sediment movement in the streams is not the end point; the NLWRA products enable better targeting of stream restoration, as needed, for example, by Catchment Management Boards and River Management Committees in NSW when implementing their plans and developing stream management actions and priorities. At the stream reach scale, rehabilitation can be adopted to provide a suitable physical environment for habitat. This important

NEW TECHNICAL REPORT

IRRIGATOR AND COMMUNITY ATTITUDES TO WATER ALLOCATION AND TRADING IN THE MURRUMBIDGEE CATCHMENT

by

John Tisdell
John Ward
Tony Grudzinski

Report 01/1

This report presents the results of a Land and Water Corporation funded research project aimed at developing an understanding of irrigator and community attitudes to water allocation and trading. This document reports the findings of a survey of irrigators and community members in the Murrumbidgee catchment. The questionnaire elicited attitudes of irrigators and community members to the Council of Australian Governments (COAG) reforms, to temporary and permanent water trading, to the impact and future of water trading, to the role of the water authority in regulating the market and to environmental issues.

Copies available through the Centre Office for $27.50.

link is provided through an Associate Project led by Bill Young and funded by Agriculture Fisheries Forests Australia (AFFA).

THE FUTURE

The management of the Murrumbidgee Catchment is in a very dynamic period. The initiatives of the Catchment Management Board, including the target setting process, are resulting in a large demand for the latest technical information. The CRC is developing a set of products that consider the whole-of-catchment.

In addition to *Catchword*, these products are communicated regularly to CRC stakeholders in Murrumbidgee and across NSW via 'Update', a short newsletter on CRC and DLWC activities, distributed quarterly by e-mail. The CRC will continue to improve the level of technical integration, and balance its effort in R&D with assisting in the current technical demands of catchment managers.

The vision of the Murrumbidgee Catchment Management Board is "A healthy productive Murrumbidgee Catchment and its communities working together-Yindyamarra" (Yindyamarra - to be gentle, polite, to honour and respect, to do carefully)". The CRC for Catchment Hydrology is helping provide the knowledge base needed to achieve it.

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[1]Vertessy, R.A. and Bessard, Y. (1999) Anticipating the negative hydrologic effects of plantation expansion: Results from a GIS-based analysis on the Murrumbidgee Basin. In: J. Croke and P. Lane (eds), Forest Management for the protection of water quality and quantity. Proceedings of the Second Erosion in Forests Meeting, Warburton, 4-6 May 1999, Cooperative Research Centre for Catchment Hydrology, Report 99/6, pp. 69-73.

[2] Implementation of a Mean Annual Water Balance Model Within a GIS Framework and Application to the Murray-Darling Basin by Andrew Bradford, Lu Zhang and Peter Hairsine (CRC Report 01/8) available through the centre office.

THE BRISBANE FOCUS CATCHMENT

by TONY WEBER and TONY WONG

THE CATCHMENT

The Brisbane River Catchment has a sub-tropical climate, with 1500mm of rainfall a year, mostly as intense summer storms. The catchment area is 13,500km^2 and extends from Moreton Bay to the Great Dividing Range. It includes 850km of river and lake banks as well as 50 major creeks.

The Brisbane River is the largest in the catchment. 80km of its lower reaches are tidal and flood prone, with eleven 'major floods' recorded in Brisbane since 1840. Land-use is varied, including significant areas of urban, grazing, cropping and forested lands; the upper catchment is mainly rural, while the lower catchment is largely urbanised. 14% of the catchment remains uncleared. The Brisbane River Catchment supports the largest population of any catchment in Queensland (in excess of one million) and is currently experiencing rapid population growth. As a consequence, there are 40 sewage treatment plants (STPs) in the catchment. In Brisbane City alone, there are over 2,100km of enclosed urban stormwater drains and 8,200km of 'kerb and channel' stormwater drainage.

The Brisbane River catchment drains to Moreton Bay (1,523km^2), which plays a major role in the economy of the region and the lifestyle of its people. For instance, Brisbane is the only place in the world where 700-900 dugong graze on seagrasses within sight of a major city. The Bay also hosts internationally recognised sites for migratory birds and supports a significant fishing industry. The Bay's recreational fishing industry alone is worth over $400M annually.

SPECIFIC CATCHMENT ISSUES

The following are the most significant waterway-related issues currently facing the catchment (in no particular order):

- Flooding (regional and local).
- Sediment loads and turbidity in creeks, the Brisbane River and Moreton Bay (from urban stormwater and rural land-uses).
- Nutrient loads in creeks, the River and Bay (e.g. algal blooms in the Western Bay are principally linked to nitrogen discharges from STPs).
- Weeds (aquatic and riparian).
- Degradation and discontinuity of riparian vegetation.
- High concentrations of nutrients, bacteria and phytoplankton in creeks within the upper catchment.
- Sewage overflows and urban stormwater impacting upon urban creeks.
- Water supply and environmental flows.
- Litter and toxicants (e.g. pesticides and heavy metals) in creeks, the River and Bay.
- Bank erosion (particularly creeks in the upper catchment).
- Efficacy of management practices.

RESEARCH ADDRESSING THE ISSUES

"South East Queensland's catchments and waterways will, by 2020, be healthy living ecosystems supporting the livelihoods and lifestyles of people in South East Queensland, and will be managed through collaboration between community, government and industry" is the vision of the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS). The Strategy has developed in stages since the mid 1990's to address the catchment issues identified above and is due to be completed in December 2001. The results of the development of the Strategy will form part of the South East Queensland Regional Framework for Growth Management.

The Brisbane River forms an important part of Brisbane's landscape and is the focus of many recreational activities and the Riverfestival.

CONFERENCE PROCEEDINGS

THE THIRD AUSTRALIAN STREAM MANAGEMENT CONFERENCE - THE VALUE OF HEALTHY STREAMS

27-29 August 2001

Brisbane, Queensland

Copies of the recent Stream Management Conference proceedings are now available for sale from the Centre Office.

The 700+ page, two volume set contains over 120 papers. Copies cost $110 (includes GST and postage) and can be ordered by contacting the

CRC Centre Office
tel 03 9905 2704
fax 03 9905 5033
email
virginia.verrelli@eng.monash.edu.au

Note: Limited copies of the Second Australian Stream Management Conference ($104.50 including GST and postage) are also available.

Brisbane Catchment

Using a task-based approach, the SEQRWQMS has focussed on key catchment issues, and uses a range of providers to research particular issues and develop management actions. Several CRC Research Programs are involved as research providers to the SEQRWQMS; these include Program 1 - Predicting Catchment Behaviour, Program 2 – Land-use Impacts on Rivers, and Program 6 - River Restoration.

As part of the SEQRWQMS, Brisbane City Council, the largest metropolitan Council in Australia, is committed to mitigating the impacts of urbanisation on the region's waterways. The CRC's Urban Stormwater Quality Program (Program 4) with its focus on characterising urban stormwater pollutants and the performance of stormwater quality management practices, is of prime importance to support the Council's and the SEQRWQMS initiatives, and to provide future directions for management actions.

MANAGING THE ISSUES THROUGH CRC OUTPUTS

Several CRC research outputs will have direct relevance to stakeholders in the catchment and will assist them in managing relevant catchment issues. From a broad perspective, the CRC's involvement in key catchment issues through four of its research programs gives a thorough scientific basis to management actions. This leads to increased stakeholder confidence and therefore rapid adoption of the research outcomes.

Bioretention system being constructed for stormwater treatment in Brisbane.

Regional Management Initiatives

Of key importance to all stakeholders in the Brisbane River catchment is the need to predict the impacts of changes in catchment management practices on in-stream water quality. Through the development of an Environmental Management Support System (EMSS) by the Predicting Catchment Behaviour Program (Program 1) of the CRC, stakeholders can now evaluate proposed development and management strategies or scenarios on a whole-of-catchment basis. The EMSS has also "captured" and integrated a wide range of research data from various sources in the catchment.

In addition to enhancing the accuracy and usefulness of the predictive tools, work is being undertaken in the programs for Land-use Impacts on Rivers (Program 2) and River Restoration (Program 6). It has been identified that riparian vegetation plays a key role in maintaining waterway health. The assessment of the effectiveness of riparian vegetation on reducing water quality nutrients, such as nitrogen, is needed given the impacts of elevated nitrogen in Moreton Bay. This research - in Project 2.5 (Nitrogen and Carbon Dynamics in Riparian Buffer Zones) - will lead to enhanced guidelines for riparian buffer zones and development of model elements that can be incorporated into the EMSS and other predictive tools. Given that riparian rehabilitation is the most common stream rehabilitation activity in Australia, it is essential that rigorous evaluation of the effectiveness of this rehabilitation be determined and incorporated into predictive tools. This work is being completed as part of Project 6.4 (Evaluation of Riparian Vegetation in a South-East Queensland Catchmen)t.

An associated project in Program 2 involves sediment and nutrient sourcing in the Southeast from individual sub-catchments with the Brisbane River catchment. The project aims to determine the relative contributions of sediment and nutrients, using tracers to distinguish between surface and sheet erosion, and gully and stream bank erosion, identifying the relative contributions. This research provides a scientific basis for targeting management actions in the catchment, with findings incorporated into the EMSS.

MANAGING URBAN CATCHMENTS

On a finer scale, Program 4's model for urban stormwater improvement conceptualisation (MUSIC) will assist urban land managers to predict the pollutant loads from changes in land-use. It also simulates practices such as Water Sensitive Urban Design (WSUD) to manage those loads. By integrating the results of MUSIC with EMSS, an enhancement of the predictive capability of land and water at a range of scales will be provided.

Fundamental research involving field experiments and catchment monitoring is being undertaken within the urban areas of Brisbane to continually improve the predicting capability of MUSIC. Recent experiments conducted on the performance of grass swales in Brisbane and performance data from a number of Stormwater Quality Improvement Devices (SQIDs) have ensured that local data on stormwater management measures is used to complement the "world database" underpinning the algorithms now used in the modelling package. Other experiments involve the monitoring and evaluation of a bioretention system and a constructed wetland (designed according to CRC guidelines) currently under construction in Brisbane at Bracken Ridge and Bridgewater Creek, Coorparoo respectively.

MUSIC is currently being trialled as a tool in developing stormwater management strategies for a number of proposed land development projects within Brisbane City and Gold Coast City. The tool is fundamental to the development and evaluation of WSUD in land development. As readers of *Catchword* would probably be aware, the CRC for Catchment Hydrology was recently awarded the CRC Associations Excellence in Technology Transfer Award due to the adoption of WSUD by industry. From a Brisbane River catchment perspective, the rapid population growth that is expected for the South East Queensland region will require land-use practitioners to manage the impacts of urban development through the application of WSUD principles if the SEQRWQMS vision is to be achieved. Due in part to the CRC's research in WSUD, Brisbane City Council is encouraging the use of this management practice by incorporating it into town planning schemes and policies.

NEW WORKING DOCUMENT

MODELLING VICTORIAN ANNUAL RAINFALL DATA

by

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Working Document 01/1

Annual rainfall data from twenty stations with long records were analysed with regard to wet and dry spells and long-term persistence. Small changes in the means and standard deviations over time were observed from the time series plots of the data.

The Hidden State Markov (HSM) model was fitted to the data and the results indicated the absence of two state persistence in the data. One hundred replicates of annual rainfall data were generated using the HSM and the widely used first order autoregressive model. The autoregressive model preserved the moments of the data better than the HSM model as these were directly input to the model. The low rainfall sums were satisfactorily reproduced by both models.

A further study is in progress using a number of stations selected across Australia and carrying out the HSM calibration with different starting months.

Copies available through the Centre Office for $22.00

Further research is also being undertaken as new WSUD elements are identified. Other local governments in the region are also adopting and fostering WSUD.

A RISK-BASED APPROACH TO LAND AND WATER RESOURCE MANAGEMENT

Owing to the complexity of the interacting meteorological, hydrological, physical, chemical and biological processes at the catchment-scale, a risk-based approach to water resources management best encapsulates the highly dynamic systems operating in catchment hydrology and water quality. Computer models such as EMSS and MUSIC are essential tools in supporting this approach. Collaborative research with other research organisations such as the CRCs for Freshwater Ecology and Coastal Zones are directed at completing the linkages of the various processes in these models. Research in Program 5 on Climate Variability is also fundamental in understanding and simulating the meteorological factors that drive these models. Ultimately, the ability to generate a number of long-term rainfall sequences for any site, (while preserving the historical statistics of that site – and thus the parameters for future events), gives us the capacity to test the sensitivity of our land and water resource management strategies to climate variability.

ENGAGEMENT OF CRC STAKEHOLDERS

Within the region there are a wide variety of stakeholders who have an interest in CRC research and the application of research outcomes. Those stakeholders with the most direct interest include:

- State and Federal Government agencies active in the region
- The diverse range of local government authorities in the region
- Land developers who are required to implement sustainable land management practices.
- Large corporations such as the Port of Brisbane Corporation and the South East Queensland Water Corporation
- Land-use consultancies who serve a variety of clients in the catchment
- Community groups, especially Catchment Care and Landcare groups
- Rural land managers such as farmers and land holders
- Industry groups such as Institution of Engineers Australia, Australian Water Association, Queensland Farmers Federation, and the Stormwater Industry Association
- Partnerships such as the new Moreton Bay Waterways and Catchments Partnership, and the existing South East Queensland Regional Water Quality Management Strategy (SEQRWQMS).

The major vehicle for stakeholder engagement in the Brisbane River Focus Catchment has been the SEQRWQMS. Using vehicles such as the development of EMSS and MUSIC, the stakeholders have been able to contribute to the content and direction of research being undertaken and have gained access to useful research outputs.

Brisbane City Council is a partner in both the SEQRWQMS and the CRC, and is also viewed as a leader in urban water management in the region. Adoption of research outcomes by Brisbane City Council thus gives stakeholders confidence in the outcomes and leads to wider adoption and application of principles such as WSUD. CRC Seminars presented in the Brisbane River catchment have also provided opportunities for stakeholder interaction and have been well received.

BENEFITS OF CRC RESEARCH

Through the CRC's close links to the SEQRWQMS, its researchers are working on the key issues in the Brisbane River Catchment. Their research is providing scientific rigour for decision support tools, land-use management practices, and on ground actions. The research outputs will result in better management of the Brisbane River catchment and waterways, and help achieve the CRC's vision; "Sustainable management of the nation's water resources through adoption of an integrated approach to land-use, water allocation, hydrologic risk, and environmental values".

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THE FITZROY FOCUS CATCHMENT

by CHRIS CARROLL, PETER HAIRSINE and JOHN TISDELL

CATCHMENT DESCRIPTION

The catchment of the Fitzroy River stretches from the Carnarvon Gorge National Park in the West to Rockhampton on the central Queensland coast. This catchment is the second largest in Australia, with an area of some 143,000km^2. It is dominated by agriculture (grazing, dryland cropping, irrigated cotton and horticulture) and mining (coal production of 100 million tonnes/year, magnesite, nickel, and historically, gold and silver).

CATCHMENT ISSUES

Sediment movement

The flow of the Fitzroy River and its tributaries is highly variable, with a seasonal bias to higher flows in summer. Limited data indicates annual sediment delivery to its estuary averages 5 million tonnes, with high levels of nutrients and some pesticides. The catchment has recognised land degradation problems including all forms of soil erosion by water, and soil fertility decline. Several existing industries and communities are barely viable in the current economic environment.

Fitzroy Catchment

Water Trading

A Water Allocation and Management Plan (WAMP) was released in December 1999, and became legislation under the water planning provision of the Queensland Water Bill 2000. The WAMP provides a basin wide framework for water allocation and management. It defines objectives for environmental flow and water entitlement security, and water and aquatic ecosystem monitoring requirements. The WAMP is implemented through Resource Operation Plans (ROP's). ROPs define the rules and strategies by which the WAMP objectives will be met. The elements of a ROP are operating rules for infrastructure, management rules to meet plan objectives, monitoring requirements, rules for conversion of existing licenses into transferable water allocations, water trading rules, and strategies for the future allocation of water.

WEB SEARCH ENGINE UPGRADED

The CRC's website search engine has recently been upgraded and is now able to search Adobe pdf files.

Over 2000 people seeking information on aspects of catchment hydrology visit our site each month.

www.catchment.crc.org.au

WHAT IS THE CRC BRINGING TO THESE ISSUES?

Sediment movement

The Fitzroy is a focus catchment for both the CRC for Catchment Hydrology, and the CRC for Coastal Zone Estuary and Waterway Management.

The Fitzroy Basin Association recognised there was an ideal opportunity to integrate and add value to the separate, yet related activities in the Fitzroy. A joint workshop, arranged by the two CRCs, used the AEAM methodology (Adaptive Environmental Assessment Management) as a tool to facilitate integration. Linking the respective research groups enabled the catchment and coastal areas to be treated as a continuum, and not as separate components.

The AEAM workshop successfully brought together researchers and stakeholders with specialised views of the Fitzroy catchment system. The workshop process forced the group to combine the collected understanding of the physical, biological and economic behaviour of the catchment from land surface to estuary. This creative process required individuals to adapt their specialist knowledge to interact with the description of other specialties.

Specific issues considered in the AEAM workshop were:

- The catchment economy and how land management changes would influence the economy
- The generation of sediment and nutrients from hillslopes, gullies and streambanks
- The deposition of sediment and nutrients in streams, on floodplains and in reservoirs
- The role of riparian management (including the use of fencing and off-stream watering) on sediment and nutrient movement, and grazing production costs and benefits
- The dynamics of sediment, nutrients and microorganisms in the estuary (including the influence of tides and the inflows from the river)
- The off-shore impacts, including the plumes of freshwater and sediment in Keppel Bay and beyond
- The production of fish in the estuary and the Bay as impacted by flow regulation and development in the estuary
- The impact of major dams upon flow regulation and the movement of sediment and nutrients.

Each of these issues was linked in an adaptive way so that the group could describe the link between action and reaction in the catchment system.

This process drew on the Department of Natural Resources and Mines' (DNRM) Integrated Quantity and Quality Model (IQQM). The model provides daily flow predictions for a range of catchment configurations including the pre-European land cover, and the current condition and likely changes associated with the development of the Nathan Dam.

Importantly, the AEAM workshop also used the recent output of the National Land And Water Resources Audit (NLWRA) work concerning sediment movement and nutrient movement through all of Australia's major streams and rivers and the behaviour of estuaries. Ian Prosser and John Parslow of CSIRO brought these impressive products - developed during the audit - to the

workshop (available soon at http://www.nlwra.gov.au/full/20_products/products. html). By adapting these products to include the proposed management scenarios, the products' capabilities were enhanced for the Fitzroy.

A core team is in the process of seeking more funds to follow on from the first workshop. A report has been drafted and the team is looking forward to building on the enthusiasm of the initial workshop.

Water trading

Under the Resource Operation Plan for the Fitzroy WAMP, there is a requirement to set Water Trading rules. The CRC's Project 3.2 (Enhancement of the water market reform process: A socio economic analysis of guidelines and procedures for trading in mature water markets) seeks a better understanding of both irrigators' and the urban communities' attitudes to water trading, and to provide guidance for future policy. Although water trading began in the mid 1980's the economic impacts on regional towns and communities are still unclear.

The CRC's survey results indicate a level of progress toward general acceptance of water reform in general, but general dissatisfaction in the reform process. There are blockages to trade that need to be addressed. Respondents to the survey see water markets in the future being limited within their region, yet playing a significant role in irrigated agriculture, increasing overall farm income and being dominated by a few large players. They do not see water markets creating significant externalities in terms of security of supply to other farmers, impacting on the environmental health of river systems, or increasing salinity.

ENGAGEMENT OF STAKEHOLDERS

The Communication and Adoption Plans developed by each program and project have been a valuable process for identifying key stakeholders in the Fitzroy and within state and regional organisations.

The Fitzroy Basin Association (FBA) is a community-based organisation that promotes sustainable development in Central Queensland. It represents those who have a stake in the use and management of the natural resources of the Fitzroy Basin and the broader Central Queensland region. The FBA recognises there is a need for greater coordination and integration of research, development, extension and adoption activities in the Fitzroy. The Fitzroy Integrated Research Development, Extension and Adoption (FIRDEA) initiative has been established in the basin as a mechanism for integrating research, development, extension and adoption activities covering economic, social and environmental elements associated with sustainable natural resource management.

As the Focus Catchment Coordinator for the Fitzroy, Chris Carroll is a member of the FIRDEA technical group; it is through this group and other forums that Chris keeps the stakeholders in the Fitzroy informed on CRC for Catchment Hydrology activities. Claire Rodgers is the Program Manager of FIRDEA, and represented the FBA at the recent AEAM workshop in Brisbane.

There is a need for the AEAM process (see above) to be continued in the Fitzroy so that a great cross section of stakeholders and landholders are engaged and have ownership in the outcomes from the process. The survey of irrigators and community conducted by Project 3.2 involved stakeholders directly. The facilitation of the survey by Chris Carroll and others from DNRM was of great assistance.

TANGIBLE BENEFITS FROM APPLICATION OF THE RESEARCH

The AEAM process is ideally suited to determine water quality targets in partnership with landholders and community for the National Action Plan. The National Land and Water Resource Audit modelling component identifies major sediment source and deposition areas in the catchment, enabling strategic priorities for on-ground works to be identified. Thus, application of the CRC's (and related) research will help get the best outcome and value for the investment dollar.

The CRC's research into sustainable water allocation has provided catchment level input for water authorities to consider when developing future water policy. The first phase aimed to gather information on the nature of water markets and to provide input into water policy development to enhance water trading. Irrigators and rural community members were surveyed to gain an understanding of their opinions on water reform, allocation and trading in the Fitzroy catchment. The survey findings thus are an important contribution, we believe, to our understanding of how people are actually responding to the new conditions for water trading and management.

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FIND OUT ABOUT CRC ACTIVITIES BY EMAIL

THE CRC WILL NOTIFY YOU OF AN UPCOMING CRC ACTIVITY IN YOUR AREA OF INTEREST

You can register to receive this information on line at www.catchment.crc.org.au/subscribe

or you can contact Virginia Verrelli at the Centre Office on 03 9905 2704.

COOPERATIVE RESEARCH CENTRE FOR

CATCHMENT HYDROLOGY

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OUR MISSION

To deliver to resource managers the capability to assess the hydrologic impact of land-use and water-management decisions at whole-of-catchment scale.

OUR RESEARCH

To achieve our mission the CRC has six multi-disciplinary research programs:

- Predicting catchment behaviour
- Land-use impacts on rivers
- Sustainable water allocation
- Urban stormwater quality
- Climate variability
- River restoration

CRC AUSTRALIA

The Cooperative Research Centre for Catchment Hydrology is a cooperative venture formed under the Commonwealth CRC Program between:

Brisbane City Council
Bureau of Meteorology
CSIRO Land and Water
Department of Land and Water Conservation, NSW
Department of Natural Resources and Environment, Vic
Goulburn-Murray Water
Griffith University
Melbourne Water
Monash University
Murray-Darling Basin Commission
Natural Resources and Mines, Qld
Southern Rural Water
The University of Melbourne
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