NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 137 MAY 2005

A NOTE FROM THE DIRECTOR

Rodger Grayson

Inside...

Recently I was asked to write an 'opinion piece' for one of the research-based hydrological journals. The editor was interested in 'this CRC thing' – the concept of a genuine industry/research collaboration across many organisations being quite novel to him. This reminded me just how special the concept of CRCs really is. After twelve years of the CRC for Catchment Hydrology, it is easy to forget that by international standards, we have been involved in an avante garde experiment. As our North American-based external reviewers noted in 2001, there was "nothing comparable" to our CRC in the United States. This was reiterated last year when a senior overseas colleague reviewed the eWater business case for us, noting that he knew of "no other effort internationally" that brings together science with well defined industry needs in such an integrated manner. Clearly we have something very special.

Next month will be our last *Catchword* and it will be devoted to summarising our major achievements and challenges for the future – the practical side of the CRC. This month, I would like to comment on some cultural aspects of our CRC - more the "how" of what we do. I suspect it is these aspects of CRCs that really fascinate our overseas colleagues, for many of whom the distance between research and industry is vast by comparison with our situation. The comments that follow are largely a distillation of discussions held at our recent Program Leaders and Focus Catchment Coordinators workshop.

There is an interesting contrast in what we do and how we do it. On one side there is a view of our CRC as a pragmatic group, focussed on the production of "tools" and "products" – a solution-oriented, "engineering culture" (by which I think people conjure up the archetypal image of the back-room technical expert). From one angle, this is correct, we clearly have a very solution-oriented culture of delivery. But the way we have gone about this is far from the cold, detached notion that tends to follow from this archetypal image. Operationally, we are heavily "relationships focussed" and spend considerable time fostering shared vision.

Face to face meetings and extended workshops have been a hallmark of our CRC - invariably with time not only for "business meetings" but also to get to know one another personally. These include all facets of our operation from high-level meetings of key Party representatives to set directions for our project rounds, to annual workshops of the whole CRC family involving over 100 people, to project level retreats. In the current age of overcommitted schedules, face-to-face meetings are almost old-fashioned, but these opportunities to listen and learn have built a depth of trust and goodwill right across our CRC. This extends from the Board down and has underpinned the efficiency of all aspects of our operation.

Fostering a shared vision has also been central to the CRC and this has resulted from many activities, but been driven by two very well defined Missions. The Mission for our activities from 1992-1999 was: The CRC for Catchment Hydrology exists to improve the understanding of catchment hydrology and its application to land and water management issues

Building on the initial CRC, our current Mission is: "To deliver to resource managers the capability to assess the hydrologic impacts of land-use and water-management decisions at whole-of-catchment scale"

These statements of our overall purpose reflect a subtle shift from the 'development of knowledge and understanding' and its application, to 'delivery of capability', consideration of larger scales and a more integrative approach. Effective integration will be central to the success of eWater, with its considerably expanded scope. We have begun to make progress in this area, at least within the more limited scope of our own CRC activities.

A major step in building the links between our activities was the "integration blueprint" process our CRC went through in 2002. This process must be close to unique in terms of building a large portfolio of research projects, virtually all with components designed to come together in integrated packages. The blueprint process is an example of our emphasis on face to face meetings, with a series being held through 2002, beginning with high-level identification of Party needs and culminating in a two day "project agreement writing workshop". At this workshop, all teams formalised what they needed to deliver to other projects and what was expected to be delivered from other projects. For this to be effective, each team had to develop a clear understanding of the requirements that other projects would have of their own work, be able to specify the detail of what they would

COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

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need from other projects, and finally accept that the delivery of their own project outcomes would be partially dependent on others. As those involved in research management will recognise, this is a situation that researchers generally try to avoid. The fact that it was accepted and even embraced is a measure of the depth of trust, goodwill and shared vision that exists across the CRC.

In the last few months we have started to see in the benefits of an integrated group of projects, with the completion of modules for E2 and the increasing linkages between many of our products such as SedNet, 2CSalt, RRL and RAP. This has happened because of a strong culture of collaboration across projects, programs and Parties. This culture is built on a high level of respect across the organisation for the variety of skills and experience needed to "deliver capability", as well as a widespread understanding of the various needs of our industry and research Parties.

Respect for skills and understanding of needs take time and effort to develop and this may be why the concept of CRCs is avant-garde to many outside Australia. We have been fortunate to have such willing participants in developing a culture that has enabled us to reach a point where genuine collaboration is not just a 'desirable outcome', it is the essence of how we do things.

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leaders
GEOFF PODGER
& ROB ARGENT

Report by Geoff Podger

Linking of E2, IQQM and WRAM

Introduction

There have been several *Catchword* articles that have discussed linking the land and water models E2, IQQM and WRAM (*Catchword* March 2004 and July 2004). We are currently at a stage of development where the linking of these models is now possible. The E2 catchment model can now be linked with the IQQM river management model which can be linked with WRAM the water trade model. The result is a very powerful whole-of-catchment modelling package, which can consider water quantity, water quality and water trade economics. For those readers that are not familiar with these models, they are discussed briefly below.

- E2

  E2, the whole-of-catchment modelling framework, supports the development of a broad range of catchment model types, from long-term, static constituent loads based on land export rates, to dynamic daily estimation of runoff flows and constituent loads. The loads can be generated, filtered, transported and routed through catchment networks with tens to hundreds of sub-catchments (*Catchword* May 2004, August 2004, September 2004, November/December 2004, March 2005 and April 2005). E2 is available from the Catchment Modelling Toolkit website (www.toolkit.net.au/e2). The version of E2 that runs IQQM is scheduled for release in July at the Catchment Modelling School being held in Brisbane and Sydney.

- IQQM

  The Integrated Quantity Quality Model (IQQM) is a hydrologic modelling tool designed for investigating and resolving water sharing issues:

  • at the inter-state or international level, and

  • between competing groups of users, including the environment.

  The model uses nodes and links to describe river systems. It operates on a continuous basis and can be used to simulate river system behaviour for periods ranging up to hundreds of years. IQQM is available from the NSW Department of Infrastructure, Planning and Natural Resources.

- WRAM

  The Water ReAllocation Model (WRAM) is an economic optimisation model that determines optimal water allocation and reallocation in terms of crop planting decisions and irrigation water requirements. As a by-product, WRAM simulates trading of water entitlements between irrigation areas, and generates water accounts for economic impact analysis. WRAM maximises the net benefit for all potential traders subject to a series of constraints, for instance, on land areas, crop growth patterns and delivery constraints (*Catchword* July 2004 and November 2004). WRAM is available from the Catchment Modelling Toolkit website (www.toolkit.net.au/wram). This version of WRAM can operate as a stand-alone model and can also be coupled to IQQM.

Linking E2 and IQQM

The way that this works in the E2 interface is quite simple. The E2 wizard provides a step where the node link network is specified. The user simply selects the option of an IQQM network and locates the appropriate IQQM system file (.sqq). E2 then uses IQQM's macro language commands to call IQQM and requests IQQM to create a summary file of nodes, links and coordinates. E2 subsequently reads this file and displays the nodes and links on the screen. For each of the IQQM inflow nodes, E2 creates a subcatchment.

The user may then choose any combination of Functional Units (FUs) and associated runoff, constituent generation or filter models within each subcatchment. The output from these models will generate the flow and constituent inputs subsequently used by IQQM.

Once the E2 system is set up and calibrated, then running the two models is as simple as hitting the run button. However, behind the scenes E2:

1. Creates an IQQM direct access input file of flows
2. Uses IQQM's macro language to open the system file, specifies the new direct access files, and asks for the minimum possible running period.
3. Sets a run period which is subsequently constrained to the minimum of the possible run period in E2 and IQQM.
4. Uses IQQM's macro language command to run the model and extract output information.
5. Saves output information within E2's time series recorder.

When E2 is running, the user does not see IQQM but may view the time series outputs from IQQM at any of the nodes or links in E2. If the user is familiar with IQQM, it can be opened and more detailed information about the run can be extracted. Note any changes to the IQQM system have to be made within IQQM; this is not currently available through the E2 interface. Some IQQM parameter changes through the E2 interface may be possible in the future through IQQM's macro language interface.

Currently the models are run sequentially, i.e., E2 is run first to generate all the inflows and loads and then IQQM is run next. This means that any feedbacks cannot be run between the two models. In the future it is planned to integrate the two models on each time step thus allowing feedbacks.

As E2 uses IQQM's macro language commands to link the two models, it may be possible to link other models such as REALM, that have a similar macro language to IQQM.

Linking IQQM and WRAM

IQQM has been modified (V7.45.0) to facilitate the linking to WRAM. Further parameters have been included in the crop factor file, regulated irrigation nodes, and a new water trade dialogue. The crop factor file now includes economic parameters for each crop and the irrigation nodes include bounds on the minimum and maximum area of a particular crop. The user can specify on what days of a year water trade is to occur. Delivery constraints to groups of nodes may also be specified. The constraints are provided to limit the amount of water trade into areas that have channel constraints on the amount of water that can be delivered.

When set up in IQQM, the water trade happens seamlessly as IQQM is running, with WRAM being called at the user specified times each year. WRAM is called in two modes: firstly, at the start of each irrigation season (summer or winter) to determine for each trading node the area of each crop to grow; secondly, to trade water between specified nodes. Note water trade also occurs when setting areas.

Behind the scenes there is a lot happening at each water trade date. The linked model:

1. Has IQQM open a WRAM input file
2. Saves information about all of the irrigation nodes
3. Determines total and peak water usage for each crop in the current season from the current date to the end of the crop. Note this takes into account pond filling requirements for ponded crops such as rice.
4. Saves the average of the total and peak water usage for individual crops.

LAST CALL FOR CATCHMENT MODELLING SCHOOL REGISTRATIONS

If you would like to take advantage of this unique opportunity to understand and apply a new generation of software tools designed to underpin improved catchment management, please visit http://www.toolkit.net.au/school to select your workshops and register on-line.

Registrations have been extended beyond 31 May until further notice however places are filling quickly in the last minute rush. Payment may be made online or an invoice can be requested.

An Adobe PDF brochure with detailed information about each of the workshops to be offered at the School can be found at http://www.toolkit.net.au/pdfs/cms05_workshops.pdf

For further information or queries contact david.perry@eng.monash.edu.au

NEW TOOLKIT SOFTWARE RELEASE CMSS

The Catchment Management Support System (CMSS) has been designed to provide long term, broad area prediction of the impacts of different nutrient management strategies on water quality in Australian catchments. CMSS has been in the market since the late 1990s and it now joins the suite of Water Quality and Catchment models available through the Catchment Modelling Toolkit.

CMSS is an appropriate tool for any group or agency involved with setting land-use policies and developing land management strategies at a catchment scale, with the primary goal of maintaining and improving water quality. It is particularly suited to use in stakeholder workshops as it can be set up very quickly to provide a quantitative evaluation of alternate catchment actions being considered by the workshop.

For further information or to download the software please visit the CMSS product page at http://www.toolkit.net.au/cmss

5. Saves information about all of the crops
6. Saves node constraint information
7. Runs WRAM, reads the input file, finds an optimal solution and writes an output file.
8. Reads WRAM the output file
9. Sets crop areas for each trading irrigation node (if operating at the start of a season)
10. Trades water between trading nodes.

This facility now allows IQQM to better replicate what happens in valleys where the temporary water trade market is active. In drier years WRAM increases the areas of higher cash crops where the higher value of water is realised and subsequently reduces less profitable crops. In years where resources dry up during the season, WRAM trades water from the crops that don't need the water to those that do and can afford it. This makes for much more efficient use of the water resources within regulated systems.

This has only been trialled in example systems, but it is hoped in the future that it will be calibrated and implemented in the regulated systems throughout NSW.

Conclusion

It is very exciting to have this sort of capability and to my knowledge this doesn't exist anywhere. Linking the models allows the impact of catchment change to be better evaluated in regulated systems. It takes into consideration the change in crop and water distribution as the reliability of supply changes as a function of land-use changes.

There is much more to come in the future with further enhancements to E2 including water ordering, irrigation modelling, salinity modelling and environmental flow assessment. We are also building tools in E2 to facilitate the calibration of the model. This is all to be delivered by the end of financial year so there is a lot of work to do over the few short weeks we have left in this Program. I confident we will succeed and I am looking for to the next release of E2 in July.

Reference

B. Yu, J. Tisdell, G. Podger and I. Salbe. 2003. A hydrologic and economic model for water trading and reallocation using linear programming techniques, MODSIM2003, pp. 965-970

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER WALLBRINK

Report by David Rassam, Daniel Pagendam and Heather Hunter

The Riparian Nitrogen Model

Introduction

In this article, we report on the development of the Riparian Nitrate Model (RNM), as part of Project 2.22 (2D): 'Modelling and managing nitrogen in riparian zones to improve water quality'. We also describe a riparian mapping tool that helps users identify riparian areas where restoration activities are likely to be most effective in reducing stream nitrogen loads.

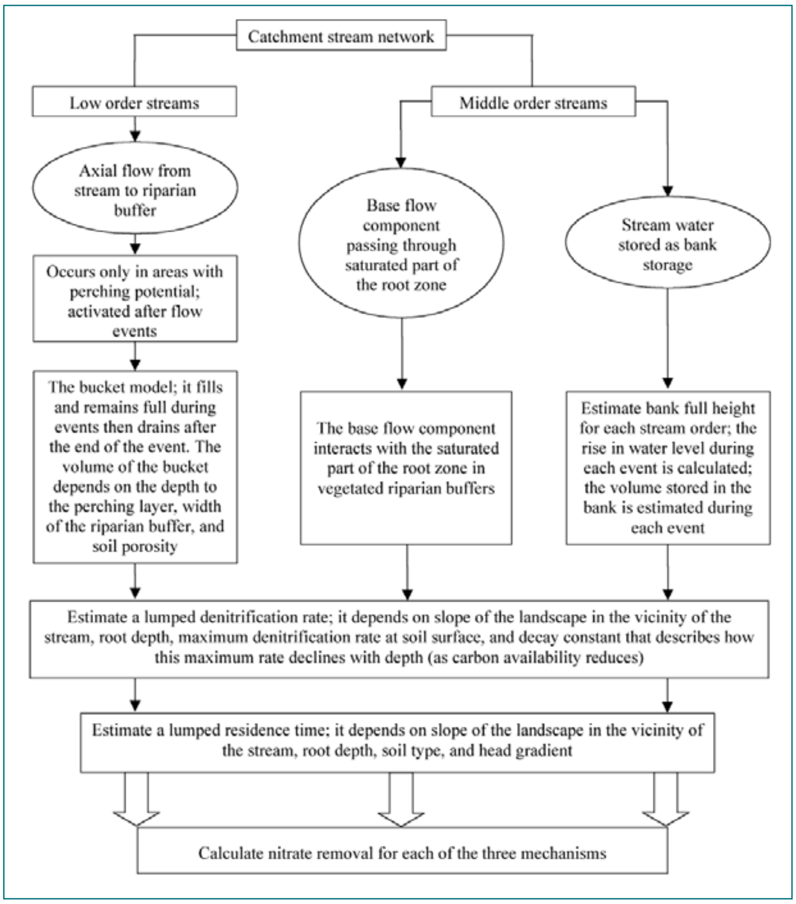
The Riparian Nitrogen Model - RNM

The RNM is a filter module within the catchment-scale model, E2, which estimates the removal of nitrate by denitrification, in situations where shallow groundwaters interact with riparian soils. The removal of nitrate reduces nitrogen loads in streams and helps minimise the occurrence of problems such as algal blooms. The RNM allows users to evaluate the effects of improved riparian zone management on catchment nitrogen budgets and water quality.

The RNM is most suitably applied in riparian buffers associated with low and middle-order streams. Nitrate removal occurs mainly via three mechanisms (shown in Table 2.1), conceptualised as follows:

- Firstly, in ephemeral low-order streams, a simple bucket model is used. Areas of potential groundwater perching are identified, where a conductive floodplain soil overlays a low-conductivity soil layer. During flood events, these areas fill like a bucket (i.e., surface water becomes groundwater); this water then loses nitrate through denitrification and subsequently drains back to the surface water system as the flood event subsides.
- Secondly, in perennial middle-order streams, denitrification occurs as groundwater (base flow) intercepts the root zone. The hydrology of the floodplain is important in determining the extent of denitrification (a shallow water table and a high residence time promote denitrification). Flat floodplains with medium-conductivity soils are most conducive to denitrification.

Table 2.1: Flow chart summarising processes described in the RNM



NEW TECHNICAL REPORT

A Tool For Mapping and Forecasting Soil Moisture Deficit over Australia

by
Durga Kandel
Francis Chiew
Rodger Grayson

Technical Report 05/2

This study provides a "proof of concept" for deriving soil moisture estimates for the whole of Australia, based on readily available information. The focus of the work is on showing how such information can be produced and giving examples of likely output of interest to environmental managers. There are many possible levels of complexity in the modelling that sits behind these methods but the authors have used simple and robust approaches in this "proof of concept".

A printed and bound copy of the report costs $27.50 and can be ordered through the Centre Office by contacting Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au

This report is also available as an Adobe Acrobat file from www.catchment.crc.org.au/ publications

SERIES ON MODEL CHOICE

The Model Choice series is designed to assist you to better understand catchment modelling and model selection.

The first publication entitled 'General approaches to modelling and practical issues of model choice' and the second in the series 'Water quality models - sediment and nutrients' are both available for downloading in PDF format from the Catchment Modelling Toolkit website at www.toolkit.net.au /modelchoice

- Thirdly, in perennial middle-order streams, denitrification may also occur when stream water is temporarily stored in banks during flood events. The amount of water stored in banks will depend on the size of the flood event, the soil properties (e.g., hydraulic conductivity and porosity), the geometry of the floodplain, and the residence time.

The nitrate loads removed via each mechanism are estimated using first-order decay kinetics. The decay rate constant (which represents the denitrification rate) varies with soluble organic carbon content and hence decreases with soil depth, as carbon levels decline. For each conceptual model, an average denitrification rate is calculated at each pixel along the stream network. This represents the denitrification potential of the adjacent floodplain and is dependent on the floodplain geometry and hydraulic parameters. The total mass of nitrate removed via each mechanism is calculated based on the denitrification potential, the residence time, and the volume of water that interacts with the floodplain.

Riparian Mapping Tool

The spatial distribution of catchment denitrification potential may also be used in conjunction with land-use data, to indicate the relative potential for nitrogen removal in different parts of a catchment. The result is an aggregated index reflecting the relative potential for nitrogen generation (which differs with land use) together with the potential for its removal (by riparian denitrification). The index categorises riparian zones that receive high scores for both nitrogen generation and denitrification potential as the most important for restoration.

The resulting maps of the aggregated index can guide managers in identifying where their riparian restoration activities may be of greatest benefit in terms of reducing stream nitrogen loads. The maps show the target areas for restoration on a pixel-by-pixel basis. The procedure is currently being trialled for the Brisbane River Catchment, with some preliminary field-testing now in progress.

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by John Tisdell

Bringing Biophysical Models into the Economic Lab: An Experimental Analysis of Sediment Trading in Australia

Introduction

Part of CRC Project 3.09 (3B): "An evaluation of permanent water markets', has been linking the CRC biophysical models, such as EMSS, with an experimental economic environment designed to explore resource economic issues and policy options under laboratory conditions.

The stochastic and unobservable nature of non-point pollution, combined with the scattered locations and intermittent operations of pollution emitters, makes the management of such pollution difficult (Baumol and Oates, 1993; Bouzaher and Shogren, 1997). Baumol and Oates (1975) argued that where the contributions of individual pollutants can be measured, emissions-based instruments, such as Pigovian taxes, cap and trade, tendering and regulation among others could be effective. As the science and monitoring underpinning biophysical models improves, traditionally considered non-point pollutants will be able to be managed more and more as point sources. In the meantime, in many catchments, such as the Minnesota River Basin, sub-catchment groups have been established with the authority to trade on behalf of those in their region (Fang and Easter, 2003).

Managing non-point pollution with EMSS

EMSS goes some way in achieving this aim. The biophysical model EMSS, and its associated components such as Sednet, allows for easy conversion of distance of riparian buffer into total suspended solid loads, thereby overcoming many of the problems associated with non-point measurement. The model, however, can only measure sediment export at a sub-catchment level, though work is currently underway to develop a model of export at an individual farm level.

Given the limitations of the current EMSS model, but with the expectation of farm level models in the future, our project work, in accordance with the study of the Minnesota River Basin by Fang and Easter (2003), implements sediment trading at a subcatchment level as a point source in order to demonstrate proof of concept. At a subcatchment level it is assumed that there are regional groups coordinating activities and have the authority to trade sediment credits and make reduction decisions on behalf of the farmers in their sub-catchment. The application of three policy instruments will be explored: a uniform price tender system, a cap and trade, and regulation.

Policy instruments

- Tenders for buffer strips, 'uniform price tenders'

  A uniform price tender involves farmers with riparian lands placing tenders with a central authority to construct riparian buffer strips to reduce sediment loads entering the river system. The government accepts the lowest price bid upwards until the reduction target is met or the budgetary constraint is met. Each seller is then paid a uniform price – the bid price of the last accepted bid.

- Limits on suspended solids loads and trading in credits - Cap and trade

  The cap and trade system, as the name suggests, involves a regulating authority imposing an upper limit on the level of total suspended solid loads exiting the system and allowing farmers to trade in sediment credits to achieve the cap. The notion of cap and trade implies that each player can potentially be a buyer or seller. When the market price is below their marginal cost of production, they are expected to enter the market and buy units rather than producing them. When the market price is above the marginal cost of producing beyond the target quantity, the player is expected to exceed their target production level and sell the additional units.

- Cap and trade applications

  The most recent and significant applications of the cap and trade approach are in the implementation of the Clean Air Act by the U.S. Environmental Protection Agency to achieve its Clear Sky objective[1] and the European Union greenhouse gas emissions-trade scheme[2]. The Clear Air Act 1990 introduced a cap and trade policy instrument on the electric utility industry in the US in order to reduce emissions (Schmalensee, *et al.* 1998; Fullerton and Metcalf, 2002; Groenenberg and Blok, 2002; Tietenberg, *et al.*, 1999).

- Merits of cap and trade

  A number of authors have explored the relative merits of a cap and trade instrument. Kuik and Mulder (in press), for example, argued that is difficult to determine the optimal policy objective using a cap and trade approach as it can achieve a variety of results and impose different transaction costs. A

NEW TOOLKIT PRODUCTS

Over the last couple of weeks a number of new Catchment Modelling Toolkit products have been released including:

IHACRES - a catchment-scale rainfall-streamflow modelling methodology whose purpose is to characterise the dynamic relationship between rainfall and streamflow, using rainfall and temperature (or potential evaporation) data, and to predict streamflow
www.toolkit.net.au/ihacres

E2 - a software product for whole-of-catchment modelling. It is designed to allow modellers and researchers to construct models by selecting and linking component models from a range of available choices. E2 enables a flexible modelling approach, allowing the attributes and detail of the model to vary in accordance with modelling objectives
www.toolkit.net.au/e2

AQUACYCLE - a daily urban water balance model which has been developed to simulate the total urban water cycle as an integrated whole and provide a tool for investigating the use of locally generated stormwater and wastewater as a substitute for imported water alongside water use efficiency
www.toolkit.net.au/aquacycle

For further information about the Catchment Modelling Toolkit visit www.toolkit.net.au

TOOLKIT SOFTWARE

WRAM

WRAM is a software application to simulate water allocation and trading between irrigation areas.

The Water Reallocation Model (WRAM) is a Windows application to simulate water allocation and trading between irrigation areas. Based on an economic optimisation model, WRAM can be integrated with hydrologic network models for assessing water resources management plans.

In addition, WRAM performs standard input-output analysis, and integrates input-output accounts in value terms with water accounts in physical units to assess the impact of water reallocation on regional economy.

You can find out more about WRAM and download the software from the WRAM web site: http://www.toolkit.net.au/wram

mixed policy of cap and trade and taxation at a regional level might be the most appropriate direction forward. Schwarze and Zapfel (2000:1) and others have found that "provisions to assure political acceptance, functional interdependencies and overlapping regulation are the most important influences on the design of applied cap-and-trade permit programs". Colby (2000) noted that cap and trade policy instruments have been applied to a number of environmental problems with varying success and that such mechanisms require a political or legal mandate to cap resource use, or in this case, emission of total suspended solids.

- Australian experience with cap and trade

  Australia is accustomed to the use of cap mechanism, such as that imposed on water extraction from the Murray-Darling Basin, but the use of markets to effectively manage the cap is relatively new, but not without precedent. Where the Project 3B work differs from the traditional cap and trade mechanism is that instead of setting a cap on emission levels, a reduction cap is set and the players have to produce the reduction rather than reduce production to meet a specific target.

- Regulation of non-point pollution

  Finally, the government could adopt a regulatory approach using a proportional reduction from each stream and river to meet the same target at that set for the uniform price closed call auction. The regulation results in a reduction of supply by each of the traders and a decrease in supply relative to the market supply curve.

Data Generation

Our work has used data from the Stanley River sub-catchment. The Stanley River subcatchment is located north west of Brisbane and is part of the Brisbane focus catchment. The catchment consists of eleven sub-catchments and in each there are opportunities to establish riparian buffer zones along the banks of the rivers and streams that flow through them.

The EMSS model has up to five types of streams in each subcatchment, from major rivers to ephemeral streams. For each there is a distance of riparian land. Within EMSS it is possible to set a sediment loading threshold rate (SLTR) expressed as tonne/km/day for each of the stream types in each of the sub-catchments.

In this study the SLTR for the five stream types was set at 1, 0.8, 0.6, 0.4 and 0.2 respectively. The notion is that level 1 streams (large rivers) will have a higher load rate than smaller streams. Simulations in EMSS were run and data captured for each stream type in each sub-catchment to end of catchment loads[3]. EMSS has two riparian treatments levels, superior and standard. The modelling used superior riparian buffer management which results in a 1 tonne per km per day sediment loading rate at sill (compared to a 0.1 loading for standard riparian buffer management). The catchment, consisting of 11 subcatchments is in the upper northern section of the Brisbane Valley. The Stanley River sub-catchment was seen as a major player in the system due to its size.

In order to avoid confounding the results due to market concentration[4], the catchment was split in two and the upper lake Summerset subcatchment was combined with the Lake Somerset and surrounds subcatchment. Simulations were run for each type of stream in each of the 11 subcatchments. The cost of riparian buffer per kilometer was assumed constant throughout the catchment at A$475[5]. The simulated load reductions were used to estimate unique cost functions per unit of sediment reduction for each stream.

Experimental design

Three experimental sessions of ten-repeated trade periods were conducted under uniform price closed call auction structures and cap and trade. Each session used eleven students, one trading units for each sub-catchment in the Somerset Stanley Catchment. The EMSS modelled estimate of the amount of total suspended solids exiting the catchment is 73,000 tonne per day.

The experiment assumed a target reduction of 10,000 tonne per day[6]. A relative cap and trade policy was explored in which each player had a specific emission target. In this experiment each player was given a target production level to represent riparian buffer management and a cost structure for up to five different types of units representing the five different types of streams in each sub-catchment.

Conclusion

The economic experiments were used to evaluate policy instruments and trading market structures for sediment runoff in the Brisbane catchment of Australia using an integrated experimental/biophysical model. The method of analysis integrated an environmental management support system (EMSS), developed for modeling sediment runoff in catchments with an experimental economic environment designed to explore resource economic issues and policy options under laboratory conditions. To demonstrate application, the model and experimental methods were applied to a case study involving the management of total suspended solids exiting a catchment.

As a proof of concept, the integration of biophysical modelling and experimental economic methods is shown to produce insights beyond those achievable using more conventional economic analysis. It opens new doors for analysing policy options where behavioural, biophysical and economic linkages are important. In the case study it was found that being able to observe behaviour, rather than assume economic optimising agents, allowed for more detailed analysis of the differences between cap-and trade and uniform tendering, which in theory should be equally efficient policy instruments.

The modelling found that:

(a) the cost of meeting the regulatory requirement is less than a uniform price auction,

(b) in a uniform price tendering there was evidence of above competitive pricing and relatively low rates of convergence, and

(c) the cap and trade produced high levels of convergence and production, which moved towards minimising the cost of achieving the cap reduction level.

The policy implications of these findings are that assuming equal efficiency of a uniform price tendering system and a cap and trade may not hold and further exploration of the relative merits of the instruments is warranted. This work is of course measuring only one metric in the policy decision-making process of catchment management. Other issues, such as the impact of riparian buffer zones on other agricultural load exports such as nitrogen and regional ecosystems are areas for future research.

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[1] For a discussion of the relative benefits of the Clean Sky scheme see Winters (2002).

[2] European Union greenhouse gas emissions-trade scheme is expected to start in 2005 (see European Union, 2001).

[3] As discussed previously, EMSS treats riparian total suspended solid loads at a block conceptual sub-catchment level. Development of the model to site-specific contributions is underway and expected to overcome many of the problems associated with the management of non-point pollution of this nature.

[4] In order to avoid complications arising from market thinness and power in CO2 markets highlighted by Liski (2001), larger sub-catchments were split and given to two players.

[5] Argent and Mitchell (1998) and McGuckian (1996) as reported in Cason *et al.* (2002) estimate the cost of installing filter/buffer strips at between $15 and $65 ha/yr. The median translates to an average estimate of $475 km/yr.

[6] A summary of the length of streams in each subcatchment, sediment loads given riparian buffers and linear models based on percentage and absolute reductions of TSS in the system is available on request.

WRAM-REALM WORKSHOP

WRAM-REALM Workshop
Modelling the Reallocation of Water from Temporary Trading

23 June 2005 , Victoria University Footscray Park Campus

REALM is a well established tool to build models to simulate the allocation and use of water in complex urban and rural water supply systems. While the REALM modelling package incorporates a wide range of capabilities to reflect the important physical, operational and regulatory features that control water allocation and delivery, it has so far not been able to satisfactorily model the reallocation of water that results from temporary water trading. As part of the 'Sustainable Water Allocation' research program with the CRC for Catchment Hydrology, a project team that included researchers and industry representatives developed an integrated modelling system (WRAM-REALM) to fill this gap.

This workshop is intended to introduce potential users of WRAM-REALM to the main features of this new modelling tool, the economic concepts and modelling principles incorporated in it, and the steps involved in its application.

The registration fee is $440, GST inclusive and covers workshop materials, as well as lunch, morning and afternoon teas. A 50% discount is available for postgraduate students and registrants from CRCCH parties participating in the project.

For further information and to register for this workshop please visit www.toolkit.net.au/training before 15 June 2005.

FRESHWATER ECOLOGY REPORT

Urban Stormwater and the Ecology of Streams

By
Chris Walsh
Alex Leonard
Tony Ladson
Tim Fletcher

Technical Report 05/4

This CRC for Freshwater Ecology Technical Report explains why urban stormwater degrades the ecological condition of urban streams, during dry, rainy and very wet conditions, but most importantly following just a little rain.

It shows how a new approach based on reducing the effective imperviousness of an urban catchment, using water sensitive urban design (WSUD) can lessen the damaging effect of urban stormwater. WSUD is a general name for a suite of measures now being used by stormwater managers and planners to intercept and treat urban water. WSUD can be applied at a range of scales, ranging from source to 'end-of-pipe'.

Bound copies are available from the CRC for Freshwater Ecology or an Adobe pdf file can be downloaded from www.catchment.crc.org.au/publications

PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

Report by Courtney Henderson, Margaret Greenway and Ian Phillips

Removal of Dissolved Nitrogen and Phosphorus from Stormwater by Biofiltration Systems

Introduction

Biofiltration or bio-retention devices are designed to treat dissolved pollutants and fine suspended particles in urban stormwater (Victorian Stormwater Committee 1999).

A biofiltration system consists of an excavated basin or trench filled with porous media and planted with vegetation. The media in biofiltration systems may range from sandy loam to gravel, and the vegetation from sedges to shrubs and small trees.

As the stormwater passes through the biofiltration system, particulates are removed by sedimentation while dissolved pollutants are removed from solution by the chemical (adsorption to media) or biological components of the system (the vegetation and biofilms). Perforated pipes under the media collect filtered water and discharge it to the stormwater network or receiving waterway.

Biofiltration systems are becoming an increasingly popular choice of treatment device for stormwater. However, very limited data exists on the effectiveness of these systems for nutrient removal.

The aim of our research was to determine the treatment efficiency of biofiltration systems for the removal of the dissolved forms of nitrogen and phosphorus, at concentrations representative of stormwater. The experimental treatments enabled us to compare the performance of three different media types for vegetated and non-vegetated experimental biofiltration systems or 'mesocosms'.

Methods

Experimental biofiltration systems or mesocosms: Small-scale biofiltration systems were constructed in 240 litre plastic containers ("wheelie bins" - 1000mm x 500mm x 500mm). The filtration efficiency of three different media types was tested using 3 mm gravel (saturated hydraulic conductivity = 180m/hr), Fine sand (saturated hydraulic conductivity = 650mm/hr), Sandy-loam ("Brickies' loam") (saturated hydraulic conductivity =30mm/hr). These treatments were further divided into vegetated and non-vegetated treatments. Each of the vegetated treatments was planted with the following five species of plants: Banksia (Banksia integrefolia) – shrub/tree, Bottlebrush (Callistemon pachyphyllus) – shrub/tree, Pigface (Carpobrotus glaucesens) – groundcover, Flax lily (Dianella brevipedunculata) – small lily, Swamp Foxtail Grass (Pennisetum alopecurioides) – tufted grass.

Figure 4.1. Biofiltration systems during experiment

The depth of the media was 815mm – leaving approximately 185mm freeboard for extended detention of water. To evenly drain the biofilters, a layer of gravel (approximately 50mm deep) lines the bottom of the bins. The pore volume of the media was estimated during miscible displacement experiments conducted prior to testing, and was estimated to be approximately 50 litres. The approximate residence time of stormwater in the soil was 4 hours 10 minutes. The bottom of each biofilter is fitted with a drainage port and tap. The biofilters were placed on open concrete bricks (besser bricks) to facilitate water sampling. The vegetated-gravel treatments have a "planting layer" of fine sand on the top 200 mm of the gravel column to support plant growth. The biofiltration systems were allowed six months to establish prior to experimentation. During this period the biofilters were watered each week with potable tap water (approximately 46 litres/biofilter). The biofilters were then irrigated with approx 108 litres of synthetic stormwater (described below) once per fortnight for 28 weeks (= 14 doses), so that the tested nutrient removal efficiency of these biofiltration systems would be representative of mature, established systems.

(The following abbreviations are used to denote the various treatments: G – Gravel, GV - vegetated gravel, S – sand, SV - vegetated sand, L - sandy-loam, LV - vegetated sandy-loam.

Nutrient removal efficiency of biofiltration mesocosms after 12 months

Dosing Experiment - 24-hour detention time experiment: The biofilters were initially flooded with tap water and saturated flow was maintained for approximately 12 hours (overnight), to flush out any nutrients that may have built up in the media interstices. The biofilters were then flooded with synthetic stormwater (chemical composition listed in Table 4.1) and the irrigation rate reduced to 12 l/h for the duration of the experiment, maintaining saturated flow. The volume of synthetic stormwater used corresponds to a storm event of the equivalent of 60mm of rain treated in a 24-hour period by a biofiltration system sized at 5% of the impervious area of the catchment. The Brisbane City Council guidelines for the protection of fresh water quality are included in Table 4.1 for comparison. Effluent samples were collected from the drain of each biofilter - hourly for the first 14 hours, and from hours 22 to 29 (one of each treatment type was tested - G, S, L, GV, SV, LV) = total 22 samples from each biofilter.

Flushing (leaching) experiment: The biofilters were dosed with 108L each of synthetic stormwater and left for 7 days, after which time the biofilters were irrigated with town water and the effluent was sampled hourly for 8 hours.

Water samples were analyzed for total nitrogen (TN) & total phosphorus (TP), Dissolved organic N and P, nitrate and nitrite (NO_3), ammonium (NH_4), orthophosphate (PO_4) and total organic carbon (TOC) (carbon results not discussed here). The nutrient removal efficiency incorporating the flushed nutrients was then calculated as follows for each nutrient and each treatment:

Mass of nutrient removed by biofiltration system = (Mass removed by 24h dosing experiment) – (calculated mass leached during flushing experiment)

Table 4.1 - Chemical composition of synthetic stormwater used to flood the biofilters.

	PO_4 mg/l	TP mg/l	NH_4 mg/l	NO_3 mg/l	TN mg/l
Synthetic Stormwater	0.40 ± 0.05	0.48 ± 0.05	0.48 ± 0.24	0.69 ± 0.12	5.44 ± 0.69
BCC Guidelines	0.035	0.07	0.035	0.13	0.65
G	0.21	0.33	0.06	1.75	6.09
GV	0.01	0.07	0.03	0.24	2.04
S	0	0.05	0.13	2.54	4.91
SV	0	0.03	0.02	0.15	1.23
L	0.1	0.13	0.02	2.69	4.06
LV	0.01	0.05	0.03	0.05	1.23

Meets BCC guidelines

NEW MUSIC VERSION 3 RELEASE

The MUSIC Development Team is pleased to announce that MUSIC v3 is now available for download from the http://www.toolkit.net.au website (you must login to be able to download the software).

There are some significant new features in Version 3: (the User Manual provides a comprehensive explanation of these new features):

- A Lifecycle Costing Module, which allows the lifecycle costs of a treatment node, or an entire stormwater treatment train, to be analysed.
- New default k and C* values for MUSIC's Universal Stormwater Treatment Model.
- New treatment nodes (Infiltration, Rainwater Tank).
- Modifications to the bioretention node to allow user-specification of the height of the collection pipe.
- Increased precision on the specification of re-use demands New Imported Data Source Node which allows an observed time series (of flow and pollutants) to be imported, for simulating situations such as point-source, or for calibrating the model to observed data.
- Improved capability to export simulation results from nodes, allowing the user to specify the timestep at which the export is done.
- Revised calculation of meteorological statistics to include zero-rainfall timesteps.

For further information and to download MUSIC Version 3 visit www.toolkit.net.au/music

NEW TOOLKIT DATA PRODUCT

Landcover Type for the Intensive Use Zone of Australia (LIZA)

The second Catchment Modelling Toolkit data product has been released on the Catchment Modelling Toolkit website.

The LIZA data cover the intensive use zone of Australia. They provide cover type estimates for 1990 and 1995, along with a first estimate of woody vegetation canopy cover percentage and canopy height. Data are available in both Geographic (on GDA94) and Map Grid of Australia coordinate systems. The spatial resolution is 0.01 degrees or 1km.

The data are derived from the Australian Land Cover Change project data sets (Bureau of Rural Sciences).

Further details and downloads are available at www.toolkit.net.au/liza

Results and Discussion

Dosing experiment (see Figure 4.2)

The concentrations in the biofilter effluent are expressed in concentrations (right y-axis) and as a concentration index (C_{out}/C_{in}, left y-axis). The concentration index describes the removal of nutrients from stormwater as a fraction, i.e. if C_{out}/C_{in} = 0.1, 90% of that nutrient is removed. Not all results are presented here.

- The vegetated treatments (GV, SV, LV) and S removed most TP (total phosphorus) from the stormwater (C_{out}/C_{in} approx 0.1, 90% removal). G and L were effective in removing 60 to 80 percent of TP.

- TN (total nitrogen) was removed from all treatments. However nitrogen removal was better from the vegetated treatments than from the non-vegetated treatments.

- The vegetated treatments removed most of the NO_3 (nitrate) from the stormwater. In contrast, the non-vegetated treatments produced more nitrate than they received in the influent stormwater.

Flushing experiment (see Figure 4.3)

- Very little TP was flushed from the vegetated (LV, SV, GV) or S treatments. However, more TP was flushed from L or G than was discharged during the dosing experiment. The phosphorus compounds trapped in the non-vegetated L or G media appear to decompose to more soluble phosphorus compounds during the intervening dry period. These compounds are leached from the media during the next flow. The vegetated treatments (GV, SV, LV) and S retained most of the trapped phosphorus.

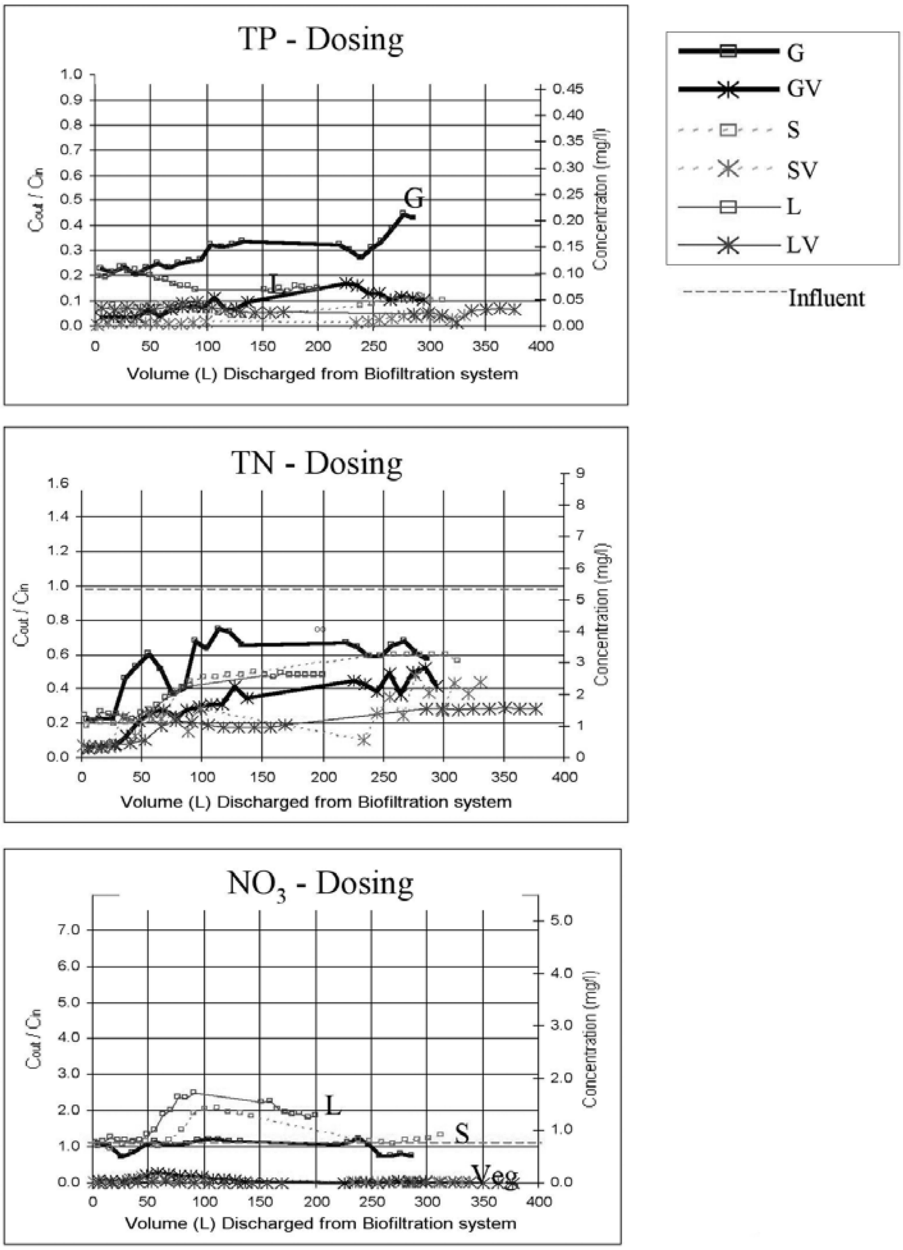

Figure 4.2. Concentration of nutrients in biofilter effluent - dosing experiment

- Very little TN was flushed from the vegetated treatments (GV, SV, LV). However, the non-vegetated treatments leached nitrogen at high concentrations, indicating that nitrogen compounds trapped in the non-vegetated media decompose to more soluble forms of nitrogen during the intervening dry period, and these nitrogen forms leach from the media in subsequent flows.
- Very little NO_3 was flushed from the vegetated treatments (GV, SV, LV). Yet very high concentrations of NO_3 were flushed from the non-vegetated treatments, concentrations higher than the nitrate used in the synthetic stormwater for the dosing experiment. This suggests that trapped complex organic nitrogen compounds are broken down to nitrate (a very soluble, simple inorganic nitrogen compound) in the non-vegetated bio-filter media during the intervening dry period. Vegetated media is able to retain most of the trapped nitrogen.

Nutrient removal efficiency

To assess the ability of these filters to treat stormwater to the recommended Brisbane City Council criteria for the protection of fresh water quality, the results for each filter (from the Dosing and Flushing experiments) were bulked and the average concentrations calculated. These results are presented in Table 4.1.

- TP and PO_4 – all vegetated systems (GV, SV, LV) and S meet BCC criteria
- NH_4 - all vegetated systems (GV, SV, LV) and L meet BCC criteria
- NO_3 - only LV meets BCC criteria, SV also provides good nitrate removal
- TN - no treatments meet BCC criteria, LV and SV gave the best treatment. Non-vegetated filters gave very poor nitrogen treatment, and G exported more nitrogen than it received.

Rank

Each treatment was ranked based on its ability to remove TN and TP. The results are presented in Table 4.2. LV and SV provide the best treatment for nitrogen and phosphorus.

Conclusions

- Sand or loam are the best media choice
- Vegetation greatly improves the removal efficiency of nitrogen and phosphorus, and vegetated media retains more nutrients during the initial flush after an inter-event dry period

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NEW TECHNICAL REPORT

Evaluating the Effectiveness of Habitat Reconstruction in Rivers

By

Michael Stewardson
Peter Cottingham
Ian Rutherfurd
Sabine Schreiber

Technical Report 04/11

River restoration is a new science and many projects are necessarily experimental. Our understanding of processes of degradation is improving but our ability to prescribe efficient restoration treatments which might include environmental flows, reintroduction of large wood debris and riparian restoration is still limited.

This report reviews approaches to river restoration. Those considering an evaluation will benefit from reading the limitations and advantages of the various approaches. River engineers, aquatic ecologists and fluvial geomorphologists now work in multi-disciplinary teams to plan river restoration work including monitoring and evaluation. In recognition of this, two chapters of this report are devoted to discussing conceptual aspects of restoration planning and evaluation as common ground across the disciplines.

Bound copies of this report are available from the Centre Office for $27.50. Contact Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au

This report is also available as an Adobe Acrobat file from www.catchment.crc.org.au/publications

NEW TOOLKIT SOFTWARE

CatchmentSIM

CatchmentSIM is a freely available stand-alone 3D-GIS application specifically tailored to hydrology based applications. It can be thought of as a collection of topographic and hydrologic analysis algorithms that have been purpose built for the process of hydrologic analysis and included in a Windows based user-friendly GIS environment.

CatchmentSIM is designed for use by anyone interested in automated catchment delineation and parameterisation from GIS data. However, the software is primarily focused on automated setup of run-files for flood and stormwater hydrograph models.

For further information visit www.toolkit.net.au/catchmentsim

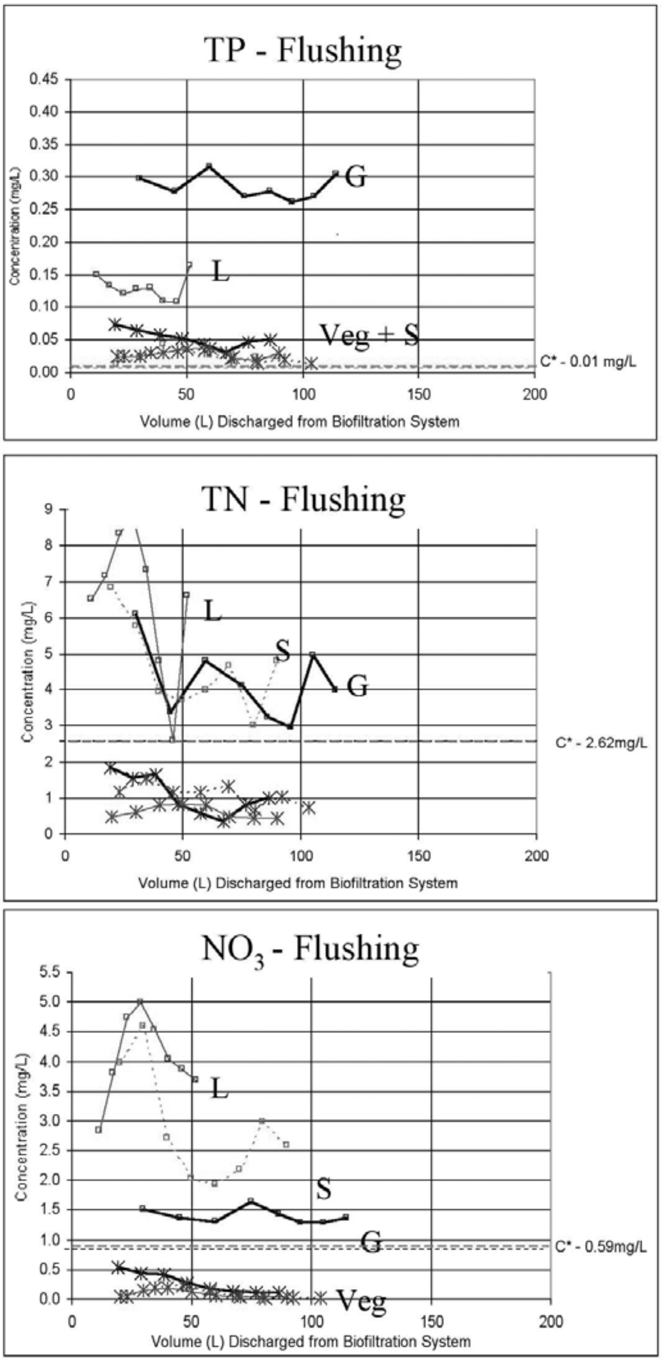

Figure 4.3. Concentration of nutrients in biofilter effluent - flushing experiment

Table 4.2. Average removal of nutrients (%) by biofiltration systems – dosing & flushing combined

Treatment	TP Removal (%)	TN Removal (%)	Rank
BCC Guidelines	85	88	-
SV	94	77	1
LV	90	77	2
GV	85	63	3
S	90	10	4
L	74	25	5
G	31	-12	6

PROGRAM 5

CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Report by Sri Srikanthan

Nested daily rainfall models

Introduction

Daily rainfall is a major input to the design of water resources and agricultural systems. As historical data provides only one realisation of the underlying climate, stochastically generated data are often used to assess the impact of climate variability on water resources and agricultural systems.

Modelling daily rainfall

Rainfall data generation is a well researched area in the hydrological and climatological literature. A common approach to modelling daily rainfall has been a two-part model in which the first part describes the rainfall occurrence (dry-wet) process and the second part describes the distribution of rainfall amounts on wet days. Rainfall occurrence is represented in two ways: either as a Markov process, the assumption being that the rainfall state on the next day is related to the state of rainfall on a finite number of previous days; or as an alternating renewal process for dry and wet sequences, the approach being to stochastically generate the dry and wet spell lengths. Once a day has been specified as wet, the rainfall amount is then generated using a Gamma or mixed Exponential distribution.

Modelling monthly and annual features

Even though the model preserves the daily rainfall characteristics, the monthly and annual characteristics are not preserved. Wang and Nathan (2002) proposed a daily monthly mixed (DMM) algorithm to preserve the monthly rainfall characteristics explicitly. In this model, two daily rainfall sequences are generated using daily and monthly parameters and the daily rainfall sequences generated from the daily parameters are adjusted using the other sequence generated from the monthly parameters. This adjustment ensures that the monthly characteristics are preserved in the generated daily rainfall sequences. However, the DMM model fails to preserve the annual rainfall characteristics.

A nested two-part daily rainfall model is developed to preserve the daily, monthly and annual characteristics. The model avoids the need to generate two daily rainfall sequences as in Wang and Nathan. The generated daily rainfall data from a two-part model are used to drive a monthly model and the resulting monthly rainfalls are used to drive an annual model. The model is evaluated using rainfall data from 20 rainfall stations located in various parts of Australia (Srikanthan 2004). A comparison of the lag one autocorrelation coefficient of annual rainfall generated by the nested two-part model and the DMM model is shown in Figure 5.1.

Improving annual variability features

Another model used widely used in Australia is the Transition Probability Matrix (TPM) model with Boughton's adjustment (TPMb). This adjustment improves the variability in the annual rainfall by scaling the rainfall amounts on wet days. However, not all the monthly and annual characteristics are preserved by this model (Srikanthan *et al* 2003). To explicitly preserve the monthly and annual characteristics, the TPM model is nested in monthly and annual models as before. The nested model is evaluated using the above data and found to perform better than the TPM or TPMb (Srikanthan 2005). A comparison of the monthly and annual correlations for the nested TPM and TPMb is shown in Figure 5.2 and 5.3.

Conclusions

The figures show that the persistence in monthly and annual rainfall generated by the nested models is better than that generated by the TPMb and DMM models. The nested two-part model is already incorporated into SCL

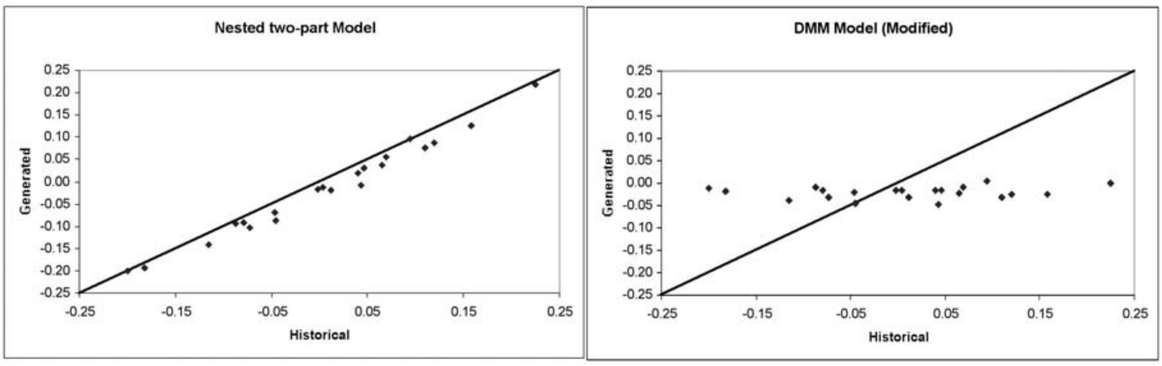

Figure 5.1. Comparison of annual correlations for the nested two-part and DMM models

NEW TOOLKIT SOFTWARE RELEASE - NSFM

The NSFM software can be downloaded from the Catchment Modelling Toolkit website.

NSFM is a non-parametric seasonal forecasting model that forecasts continuous exceedance probabilities of streamflow (and any other hydroclimate variable). NSFM forecasts the exceedance probabilities of streamflow several months ahead by exploiting the lag relationship between ENSO (El Nino/ Southern Oscillation) and the serial correlation in streamflow.

NSFM is designed for hydrologists, managers of storage systems, water users, consultants and researchers to facilitate probabilistic forecasting of streamflow several months ahead. The forecasts can be used to provide probabilistic indication of future water availability, to make better informed risk-based decisions for farm and crop management, and to make better operational decisions on management of storage systems and water allocation for competing users.

NSFM requires a continuous monthly time series of streamflow and a continuous monthly time series of an ENSO indicator as input data. NSFM provides outputs of model calibration diagnostics, forecast skill statistics and the exceedance probability forecasts.

For further information and to download please visit http://www.toolkit.net.au/nsfm

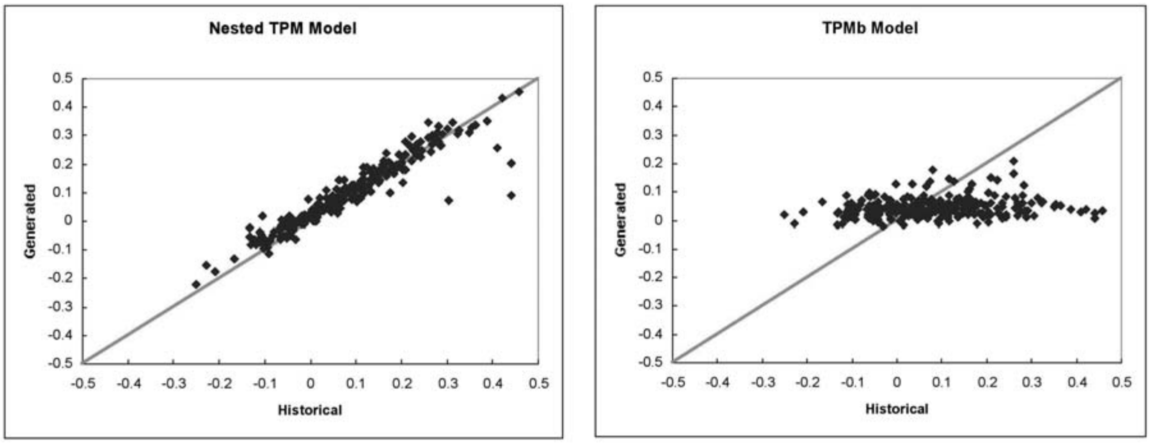

Figure 5.2. Comparison of monthly correlations for the nested TPM and TPMb models

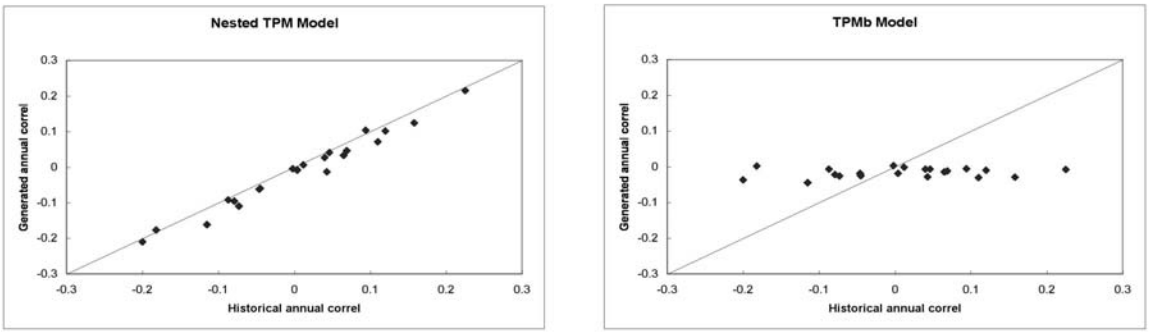

Figure 5.3. Comparison of annual correlations for the nested TPM and TPMb models

(Stochastic Climate Library in the CRC for Catchment Hydrology Modelling Toolkit) in the daily climate model. The nested TPM model for the generation of daily rainfall will be incorporated into later versions of SCL.

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PROGRAM 6

RIVER RESTORATION

Program Leader

MIKE STEWARDSON

Report by Ciaran Harman, Nick Marsh, Sylvain Arene

Time Series Manager Module of River Analysis Package

Introduction

The River Analysis Package has expanded from a software implementation of the Flow Events Method of environmental flows analysis (Stewardson *et al*) to a sophisticated set of tools for analysing the fluvial environment.

RAP has been designed to be adaptable to the rapidly expanding and changing needs of aquatic ecology. There are many tools available for constructing statistical models with multiple habitat drivers and interactions between ecosystem elements. Our solution has been to create a framework to capture our existing range of ecological response models, as well as allow future models to be included, without the need for a software engineer to recode each model as it becomes available.

Models in River Analysis Package

The River Analysis Package (RAP) contains four modules:

- Time Series Analysis module (TSA)
- The Hydraulic Analysis module (HA)
- Time Series Manager module (TSM) and
- Ecological Response Models module (ERM)

All four of these perform very different roles, but are linked together to form a complete tool. They have expanded to the point where a *Catchword* article is too short to even begin to describe them all! Here we are going to talk briefly about the Ecological Response Models module, which will eventually form the heart of RAP, and the Time Series manager, which has just been made available in the latest release of RAP.

Ecological Response Models (ERM)

The name is bit of a misnomer because ERM is a framework for capturing ecological models rather than just a list of canned models. Its key feature is to allow the user to create models or select them from a database. The models are described in terms of a biological response to a single or multiple time-variant driver such as flow, physical habitat, water quality, temperature or anything else you can think of. ERM can then run these models using the analysis and number crunching capability of the other three modules. The

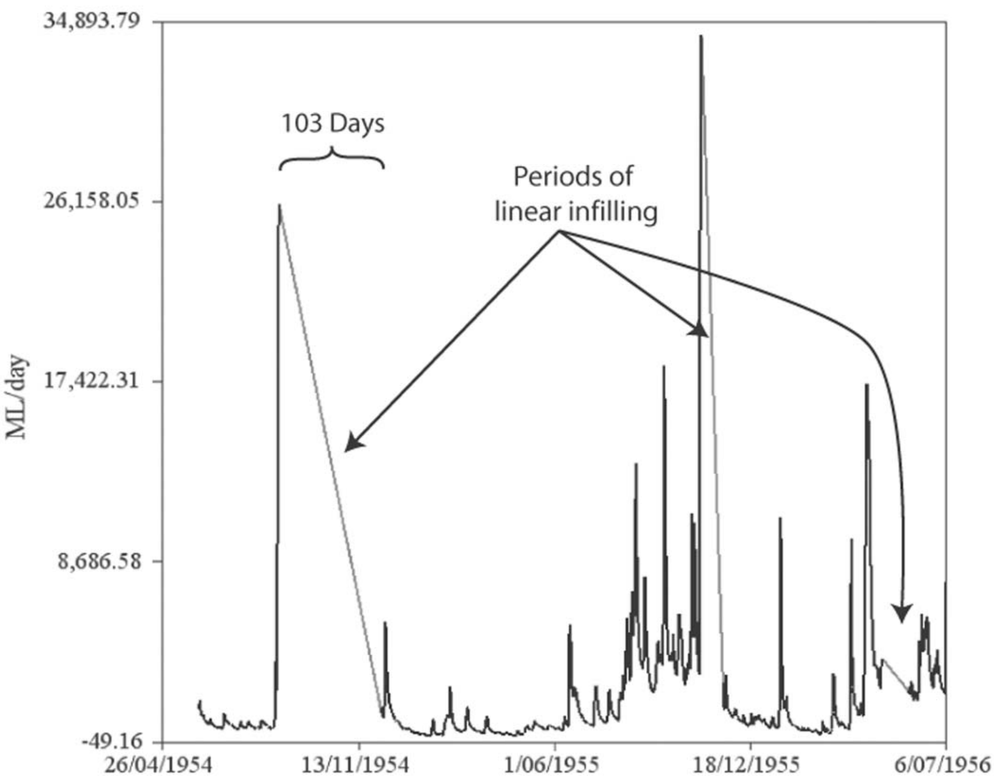

Figure 6.1: The Time Series Manager contains a tool for searching for periods of inappropriate infilling in time series.

NEW RIVER ANALYSIS PACKAGE (RAP) VERSION 1.3

The River Analysis Package version 1.3.0 now includes a completely new module for managing time series data as well as the existing Hydraulic and Time Series Analysis modules.

The Time Series Manager module includes features to:

- Identify gaps in time series data,
- Fill those gaps using some simple methods,
- Identify sections of time series data that have been filled using linear regression,
- Change the time step of time series,
- Transform time series using a user defined rating curve (aka habitat preference curve), and
- Transform or combine time series using the time series calculator.

In addition this release includes:

- A new method of visualising spell analysis output 'event domain' in the Time Series Analysis module,
- A more flexible and easier way to visualise flood frequency analysis the the Time Series Analysis Module, and
- The ability to create rating curves (aka habitat preference curves) using modelled point-velocity instead of cross-sectional average velocity in the Hydraulic Analysis Package.

The three existing RAP modules now provide all the functionality for creating models of ecological response. The final module to store and communicate these user defined ecological response models is also nearing completion.

For further information and to download please visit http://www.toolkit.net.au/rap

Time Series Manager is the last of these three modules to be completed and is now available in the RAP package.

Time Series Manager (TSM)

The Time Series Manager is a tool for cleaning up and manipulating time series. It is not to be confused with the Time Series Analysis module, which performs statistical analysis on time series.

TSM does four things. Firstly, it provides a set of Gap Tools for finding and infilling the gaps in your data. Dealing with gappy data is a perennial problem for those who use time series. In TSM gaps can be searched for and filled by either linear interpolation or using multiple linear regression with correlated time series. There is also a tool for finding periods of linear regression in data. A lot of publicly available flow records contain extensive periods of inappropriate infilling (Figure 6.1). TSM contains a tool for removing this, so that it can be infilled using more appropriate techniques.

Secondly, TSM contains a TimeStep Tool for changing the time-step of a time series. This is another common, but time consuming, activity. Time series can be aggregated to produce daily, weekly, monthly, seasonal and annual time series, on the basis of the mean, min, max, sum or a percentile of the original time step values. Thus a time series of daily flows can be instantly transformed into one of annual maxima, or mean monthly, or seasonal median flows. The time series can also be disaggregated to a smaller time step. At the moment only simple disaggregation using a constant value is available.

The third thing TSM does is allow the user to input and manipulate rating curves and apply them to time series, using the Transformation tool. In this context a rating curve is anything that relates the value of the time series, such as flow in m^3/s, to some other parameter, such as the area of deep still water in a reach at that flow. Applying this rating curve to a time series of flows would result in a time series of the area of deep, still water in the reach.

Finally, the central number crunching element of TSM is the Time Series Calculator. This calculator allows you to enter any formula using time series as variables, and calculate a new time series as a result (Figure 6.2). These 'time series models' can be stored in the ERM module, along with meta-data describing their derivation and appropriate use.

Combining module features

Let's see an example of how these features might be used together.

For instance, you might be interested in the migration of a species of fish up a reach. This species requires particular conditions of depth and velocity over riffles to be able to pass them, and needs rest areas in eddies along the stream length. ERM might contain models for both of these. These models interact with the Hydraulic Analysis module to create rating curves that describe:

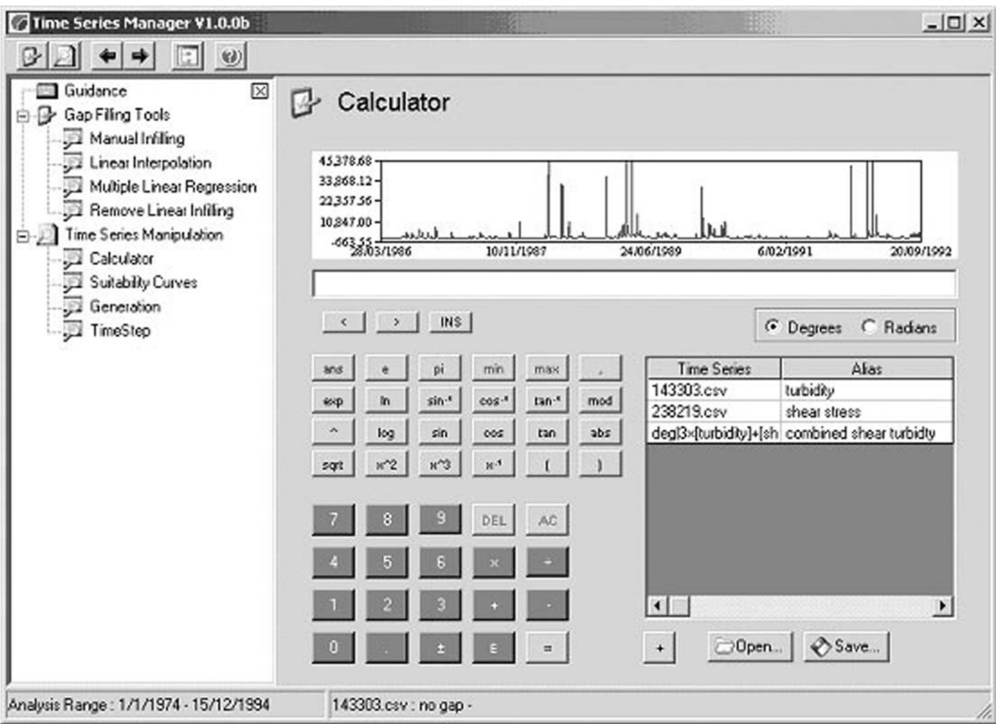

Figure 6.2: The time series calculator

1) when the riffles can be passes (as zero=no passage, 1=passage) and 2) the area of deep, still water in the reach.

These two rating curves can be applied to a time series of hourly flows in the reach using the Transformation Tool and, then multiplied together using the Time Series Calculator. Because the first time series is zero when the riffles cannot be passed, the resultant time series is the area available for rest while fish passage is possible.

Finally, this hourly time series can be aggregated to the daily scale and exported to the Time Series Analysis module to analyse the temporal patterns of availability.

Access to TSM
TSM is available in the latest version of RAP, and can be downloaded from the Toolkit Website. www.toolkit.net.au/rap

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NEW TECHNICAL REPORT

How Does Riparian Revegetation Affect Suspended Sediment In A Southeast Queensland Stream?

By
Nick Marsh

Technical Report 04/13

This project aimed to quantify the affect of a commonly adopted stream rehabilitation strategy on a small stream in southeast Queensland. The stream rehabilitation strategy was to exclude stock by fencing the stream, provide offstream stock watering and to revegetate the riparian zone using endemic native species for a 1.5 km2 catchment (Echidna Creek) near Nambour in southeast Queensland.

Four key elements were monitored through the life of the project:
1. Suspended sediment load;
2. Channel morphology;
3. Water temperature;
4. Aquatic macrophyte growth.

The results of the suspended sediment response to revegetation are presented in this report. The other key research areas are presented in separate CRC for Catchment Hydrology technical reports.

A printed and bound copy of the report costs $27.50 and can be ordered through the Centre Office by contacting Virginia Verrelli on 03 9905 2704 or email crcch@eng.monash.edu.au

This report is also available as an Adobe Acrobat file from www.catchment.crc.org.au/ publications

COMMUNICATION & ADOPTION PROGRAM

Program Leader
DAVID PERRY

At a glance – a summary of this article

Registrations for the 2005 Catchment Modelling School will be almost closed around the time you receive this edition of *Catchword*. If you still haven't registered for any Sydney and Brisbane workshops, visit the School website at www.toolkit.net.au/school The remainder of this article discusses different training strategies and the proposed role of eWater in addressing our industry's training needs.

This May *Catchword* is the second last edition ever. From 30 June 2005, as many readers will know, our CRC will cease to formally exist and will be replaced by the eWater CRC with a new mission and strategic objectives. Consequently the Catchment Modelling School scheduled for Brisbane and Sydney during July 2005 really is the last great event for our CRC. Ironically the first day of the first School in Brisbane commences on the last day of CRC, but what a way to finish with nearly 60 workshops in three weeks!

My main message is very simple. If you haven't registered for the Catchment Modelling School and you wish to do so, then please visit www.toolkit.net.au/school immediately. Registrations for both the Brisbane and Sydney Schools are scheduled to close on 31 May 2005 – perhaps around the time you are reading this article.

The scale of the Catchment Modelling School means that we need to operate with a significant lead time and the three weeks between registrations closing and the commencement of the School is quite tight. All the venue preparation and logistics, catering and printing of documentation must be completed as early as possible to ensure that each workshop runs smoothly. As I write this article, we have over 300 workshops places confirmed with some workshops having only a handful of places left. As mentioned above, the official closing date for registrations is 31 May, although if last year is anything to go by, the flood of last minute enquiries mean we will be accepting registrations for a couple of days past this date – but be warned, workshops are filling fast!

The Catchment Modelling School reflects the CRC for Catchment Hydrology's 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. The School is primarily about building skills in industry and research groups to better utilise the advancing science and technology. For this reason colleagues from outside the CRC are also invited to offer workshops that contribute to that mission.

Workshops at the school such as "An Introduction to Catchment Modelling" will also provide support for those with less experience and training in the use of the modelling capability the CRC is offering. This approach to training and education can be thought of as a "top-down" model – activities designed to meet our overall Mission.

So will this be the last Catchment Modelling School? I suspect not, since the new eWater CRC will build on the successful research and delivery strategies of the Freshwater Ecology and Catchment Hydrology CRCs. A key role outlined in the eWater business case is to provide training to meet our participant's needs and also the needs of the broader land and water management industry. eWater is therefore likely to continue the Catchment Modelling School workshops into the future, subject to reviewing its suitability along the way. It may be that we could offer more regular 'theme-based' groups of workshops targeting particular groups of professionals.

There are also many excellent examples of training courses where the technical needs of individuals, rather than their organisations primarily drive the training design, development and delivery – a more "bottom-up" approach. An example that springs to mind is the Clearwater program established a few years ago in Victoria (see http://www.clearwater.asn.au/). Led by Jacqui White and Nina Keath, this program has rapidly established itself as a high quality supplier of training that meets the needs of Victorian local government water managers and planners. Courses are offered regularly and are often developed based on through market research and analysis of specific market segment needs.

There is considerable scope for the eWater CRC to continue to develop training based on both models, for example, expanding on some of the primarily on-line courses developed and delivered by the CRC for Freshwater Ecology including the 'AUSRIVAS', 'Waterway Assessment' and 'Ecology and River Function' courses (follow the links from http://freshwater.canberra.edu.au).

eWater CRC will be seeking to collaborate with existing programs such as Clearwater in Victoria and other focussed training organisations elsewhere around Australia. Similarly small to medium enterprises already established and delivering training to other industries represent excellent opportunities to broaden the scope of possible training courses.

There is no doubt that the next few years will see a strong commitment by eWater CRC to both top-down and bottom-up models for training and development in the water management sector and often in partnership with many others. Exciting times indeed!

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2005 CATCHMENT MODELLING SCHOOL

BRISBANE
30 June - 8 July 2005
at Griffith University, Brisbane

SYDNEY
14 - 22 July 2005
at the University of Sydney

The 2005 Catchment Modelling School represents a unique opportunity to understand and apply a new generation of software tools designed to underpin improved catchment management.

The School offers over 30 hands-on modelling software workshops delivered by some of Australia's best catchment modellers.

The 2005 Catchment Modelling School targets all professionals in the hydrologic and natural resource management community.

Places are filling quickly in many workshops. For further information and to register visit http://www.toolkit.net.au/school

CRC PROFILE

Our CRC Profile for May is:

Andrew Frost

28, Virgo, M.

Stuck with the task of describing one's background, it is difficult to know where to begin. So if all else fails; read past issues.

On the first day… I was born to caring and quarrying parents in Toowoomba, Queensland (hi Helen and Mal!). In this nurturing environment of blue metal dust and bananas, I gained an appreciation for beer, engineering and facial hair at age three. Actually, the engineering came later in life.

From Toowoomba we moved to Maitland in the Hunter Valley, NSW; where I have spent most my life. A lovely place to grow up. Of course being so close to Newcastle and Port Stephens, I love the beach – and can think of few things more enjoyable than bodysurfing (programming in Fortran doesn't come close!).

Eventually I trundled off to The University of Newcastle, and completed an environmental engineering degree. I was lucky enough to do a PhD there also; which contained many hours of intellectual stimulation (read coffee, frisbee and squash) – along with the dreaded 'write up'.

My PhD happened to be on stochastic rainfall generation – which led me into my current position as a researcher with the CRC for Catchment Hydrology. I have been residing in sunny Melbourne for the last two years, located in the Hydrology Unit of the Bureau of Meteorology. Working under Program 5: Climate Variability, this work has involved creating, evaluating and adding new models to the 'Stochastic Climate Library' – and becoming familiar with the infinite beauty of Fortran and mixed language programming.

As for hobbies, I occasionally pretend I am a musician, wielding the trombone with unnerving abandon. My acoustic guitar gets a workover as a therapy tool; although my partner does not find it so relaxing over the top of the vivid representation of contemporary society that is Neighbours. I enjoy sport; when I say the word football, I mean it.

As for the future, I am about to pull up stumps and head overseas for a little while. I'll take this opportunity now to thank those members of the CRC who I have worked with most closely (especially Sri, Francis & Jean-Michel); it has been an interesting journey. With luck eWater will provide an equally positive environment for collective work.

Andrew Frost

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WHERE ARE THEY NOW?

Report by Dominic Blackham

Since leaving Melbourne University in July 2004, I've been working for a small consulting firm called Ecological Engineering (EE), set up by Associate Professor Tony Wong and Dr Peter Breen (latterly of the CRCs for Catchment Hydrology and Freshwater Ecology respectively). EE is in many ways a home from home for CRC researchers – half of the staff in the Melbourne office have a previous affiliation with either the CRC for Catchment Hydrology or the CRC for Freshwater Ecology!

Like many other postgraduates, a fantastic employment opportunity presented itself before I had submitted my PhD thesis. Getting married last November and carrying out a top-to-bottom home renovation slowed my progress towards the doctorate, but the final thesis draft is currently being reviewed by my supervisors (Associate Professor Ian Rutherfurd and Dr Mike Stewardson, both of Melbourne University) and I'm aiming to submit in the next month.

My research considered the influence of pasture grass on stream channel geomorphology. Although by no means the most ecologically interesting plants in the Australian fluvial landscape, pasture grasses such as Phalaris spp. are common in riparian areas of Victorian streams, yet their influence on stream channel processes remains relatively unknown.

The study was based around a series of flume experiments that determined the erosion resistance of various grasses, and detailed hydraulic models of a number of Victorian streams that quantified hydraulic force in stream channels. The key study outcome was that the erosion resistance of mature pasture grass is high enough to prevent erosion in many Victorian streams.

Since joining EE as a Senior Environmental Scientist I've had the opportunity to develop and apply the stream restoration skills and knowledge developed during my time at the CRC (and previously in the UK), and get to grips with a range of other integrated water resource management issues. Although EE is a consulting firm, the research background of the Directors and senior staff allows us to remain close to water resources research carried out by the CRC and others, and apply those technologies to our consulting work.

On a personal note, I've now been married for six months and have happily settled in Melbourne. Now, if England can only win the Ashes this year…

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eWATER CRC STARTS JULY 2005

eWater CRC is a cooperative joint venture focusing on enterprise, environment and education in Australia's water industry. Its vision is to be a national and international leader in the development, application and commercialisation of products for integrated water-cycle management.

The eWater Cooperative Research Centre incorporates new participant organisations as well as those from the existing successful CRCs for Catchment Hydrology and Freshwater Ecology. It combines the two water CRCs' and the new participants' partnerships, skill bases, end-user networks, intellectual property and business systems.

eWater CRC's product portfolio is based on the needs of its participants and the broader water market in:

- river operations and management,
- urban water systems,
- water and contaminant accounting,
- river and catchment restoration,
- integrated monitoring and assessment,

as well as education and training to build capacity in the water industry and community groups.

For further information about eWater CRC and its operations, please visit www.ewatercrc.com.au

COOPERATIVE RESEARCH CENTRE FOR

CATCHMENT HYDROLOGY

Print Post Approved
PP338685/00026

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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 Infrastructure, Planning and Natural Resources
Department of Sustainability and Environment, Vic
Goulburn-Murray Water
Grampians Wimmera Mallee Water Authority
Griffith University
Melbourne Water
Monash University
Murray-Darling Basin Commission
Natural Resources and Mines, Qld
Southern Rural Water
The University of Melbourne

Associates:
Water Corporation of Western Australia

Research Affiliates:
Australian National University
National Institute of Water and Atmospheric Research, New Zealand
Sustainable Water Resources Research Centre, Republic of Korea
University of New South Wales

Industry Affiliates:
Earth Tech
Ecological Engineering
Sinclair Knight Merz
WBM

www.catchment.crc.org.au