NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 109 SEPTEMBER 2002

A NOTE FROM THE DIRECTOR

Professor Rob Vertessy

PLANTATIONS, RIVER FLOWS AND RIVER SALINITY

In a recent paper published in the e-journal 'Land Use and Water Resources Research', Ian Calder argued that there is a significant disparity between public and science perceptions of the hydrological role of forests and plantations (see http://www.luwrr.com). Some old myths like 'forests generate rainfall' and 'forests increase runoff' persist, as do some more contentious assertions such as 'forests regulate flows'. The Australian public is probably better informed than most about such issues, yet even in our natural resources management sector, several unproven notions about the virtues of plantations are regarded as truths. For instance, we commonly hear that 'plantations will reduce river salinity'. Also, few people seem to appreciate that plantations will probably consume more water than the other forms of land cover that they replace, reducing water yield from catchments.

According to the latest National Plantation Inventory Report, a further 86,000 ha of plantations were added to the national estate in 2001, a growth rate of 6%. Most of the recent expansion has been in hardwood plantations established in Victoria, Western Australia and Tasmania. These figures reveal that Australia is indeed well on track to achieving the shared industry and government vision of trebling our plantation area by the year 2020 (an aspiration referred to as The 2020 Vision). Increasingly, those observing these developments are giving consideration to the hydrologic impacts of such dramatic land-use change. Our CRC is continuing to make a leading technical contribution to the debate on this issue.

Last month, I was asked to speak at a national conference entitled 'Prospects for Australian Forest Plantations 2002', organised by the Bureau of Rural Sciences and the Australian National University. An array of experts gave presentations at that meeting, viewing plantation development through various prisms, including economics, markets, environment, social impact, biodiversity and carbon balances. It was a fascinating gathering on a hot topic of vital importance to the national interest. The conference highlighted that there are many benefits to be gained from a growing plantations sector, but that there are some potential problems too.

My talk, entitled 'Plantations, River Flows and River Salinity' focused on the hydrologic and salinity impacts of plantation development. I drew on extensive research undertaken jointly by our CRC, CSIRO Land and Water and the Murray-Darling Basin Commission (MDBC). I made reference to field observations and modelling results that reveal the extent to which river flows and river salinity could be modified by land-use change from agriculture to commercial plantations. The central thesis of my talk was that the possible reductions in water yield are sufficiently large to warrant careful consideration of where we establish new plantations. I also argued that broad-scale afforestation of agricultural areas could actually exacerbate river salinity problems before fixing them, and that improvements may not even eventuate. Once again, the key to improving river salinity (and guaranteeing water security) is putting the plantations in the right place. My belief is that we have the necessary modelling tools available to make informed decisions in this regard.

At an earlier conference on this topic, Kevin Goss of the MDBC noted that water allocations are extremely tight in the Murray-Darling Basin, with over 96% of the allocation going to an irrigated agriculture industry worth $4.5 billion per year. The government policy response to this problem has been: (i) to place a cap on water extractions, (ii) to introduce water trading aimed at stimulating the transfer of water to more efficient and higher value enterprises, and (iii) to enact legislation to control further farm dam development. Concurrently, Commonwealth and State governments are seeking to allocate more water to the environment.

I argued in my talk that, given these efforts, it is surprising that no regulatory framework exists to control the water resource pressures that are exerted by plantation forestry (as there is for farm dams in some States). Given the future need to allocate more water to the environment and the need to provide water security to water users, it seems prudent, in my view, to implement some kind of system whereby new allocations of water to plantations are off-set against trades of water away from other land uses. One might argue that, given the beneficial environmental services offered by plantations (eg. biodiversity and carbon uptake or sequestration), trades of water into plantations should be subsidised. Such issues should be considered in the

Inside...

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

NEW TECHNICAL REPORT

THE STATUS OF CATCHMENT MODELLING IN AUSTRALIA

by

Frances Marston
Robert Argent
Rob Vertessy
Susan Cuddy
Joel Rahman

Report 02/4

The CRC for Catchment Hydrology is developing a new generation of catchment models and modelling support tools, integrated within a system of software known as the Catchment Modelling Toolkit. The purpose of the Toolkit is to improve the standard and efficiency of catchment modelling, and to provide much-needed enhancements in predictive capability for catchment managers.

This report describes a vital element of the planning underpinning the development of the Toolkit concept. It summarises the results of three different surveys that gauged the opinions of catchment managers, model users and model developers with respect to the status of catchment modelling in Australia.

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formulation of a rational policy and legislative framework to manage plantation development, a framework that includes consideration of water resource impacts. My hope is that our CRC can work with government and the plantation and water industries to underpin such a framework with the good scientific understanding that we have developed on this topic.

Note: A copy of the paper 'Plantations, River Flows and River Salinity' by Rob Vertessy, Lu Zhang and Warrick Dawes can be obtained by emailing Tanya Jacobson at crcch@csiro.au.

Rob Vertessy
Tel: (02) 6246 5790
Email: rob.vertessy@csiro.au

PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

What is the catchment modelling toolkit?

Over the past few weeks I have been trying to familiarise myself with what has been happening in Program 1 and what is planned to be delivered by the end of the year. One of the first questions I asked was, 'What is the Catchment Modelling Toolkit?' This is the sort of question that I have also heard a lot of other people ask. Unfortunately the question is not easily answered.

Currently the toolkit is a collection of programs such as ICMS, TARSIER, EMSS, local scale EMSS, TIME and the rainfall-runoff library. All of these products have been discussed in previous *Catchwords*. There are also a host of other tools, such as the stochastic data generation models from Program 5, that are to be incorporated into the toolkit. So in response to the question, essentially the toolkit is not a single identifiable entity.

The reason that a single product does not exist is that over the past three years a lot off effort has been put into researching, developing, and prototyping various modelling approaches. A lot of the research has been done and now we need to gather this information together and produce a product, the Catchment Modelling Toolkit.

The Catchment Modelling Toolkit
Over the next few months one of the major priorities of Program 1 is to give the toolkit an identity. This will require close collaboration with Program 7: Communication and Adoption.

The development of the toolkit is going to be a staged approach with it evolving over the next three years. The first step will be to develop a splash screen with links to some of the tools that have already been developed. The first tool to be included will be the rainfall-runoff library that is currently ready for beta testing. The next stage will be to include links with the industry models, REALM and IQQM. Then to gradually add links to other models developed within the CRC for Catchment Hydrology.

There are some problems with this approach. Firstly, there will not be a consistent style throughout the toolkit, and secondly, there are issues of software and licensing arrangements. I believe that these issues can be dealt with and that it is important to get a product available for beta testing and to give the toolkit an identity.

In the longer term the toolkit will be developed to have a consistent style as the various models get incorporated into the toolkit modelling environment.

Documentation and standards

The issue of the style, look and feel of the toolkit will be discussed over the next few weeks with the aim of releasing a standard. This standard is not fixed and it is anticipated that it will evolve - based on feed-back from people testing and using the toolkit.

Documentation standards and styles will also be considered. It is anticipated that documentation will be provided as User, Reference, Programmers, and Training Manuals.

The documentation will be provided in formats that can be printed, used for on-line help, and published on the web. Protocols and methods for version control of documentation will also be developed. Documentation version control will be managed by software that is already in place for software version control.

The developers of the various modules that are to be included in the toolkit will be responsible for providing documentation. The Programmers Manual will be automatically generated from the code.

Software licensing arrangements

Software and licensing arrangements were previously discussed in June *Catchword*. The issues raised will need to be explored with the various participants that have a stake in the software that will reside in the toolkit. This will be an ongoing issue as more software is included in the toolkit.

Geoff Podger
Tel: (02) 9895 7480
Email: gpodger@dlwc.nsw.gov.au

PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Report by Lu Zhang and Warrick Dawes

Afforestation and Water Security: An example for Goulburn-Broken Catchments

Drought and afforestation

An article in the Weekend Australian showed a picture of a bridge over the parched upper reaches of Lake Eildon taken in August. From the picture you can clearly see that the water level has dropped to its minimum. This is a result of the drought gripping the eastern part of the country and Lake Eildon is now at just 24 per cent of its capacity. What does this all mean? Well, one of the consequences is that the farmers in the region have been forced to pay record prices for water. It is a fact that water is already overcommitted in many parts of the country and things will become worse during droughts. Will large-scale afforestation add further pressure on water security? How will flow regimes be affected as a result?

Water yield studies

A number of studies have showed that trees generally use more water and mean annual water yield from a catchment would be reduced as tree area increases. One of the main objectives of Project 2.3: 'Predicting the effects of land use changes on catchment water yield and stream salinity' was to predict the impact of afforestation on mean annual water yield and a rational function approach was developed for this purpose. While changes to mean annual water yield are important, the impacts of afforestation on seasonal flows can also be significant from both environmental and water security perspectives.

Impacts of afforestation on flows

Afforestation is expected to decrease storm-flow volumes and the magnitude of peak flow. The deeper-rooted trees will create a larger soil water store, which will allow for a greater proportion of storm rainfall to infiltrate into the soil instead of running off directly. These effects are expected to be more significant for smaller storms and least significant for large storms. Activities associated with afforestation such as development of roads and drainage ditches will also affect storm-flow. However, it is more difficult to draw general conclusions about their impact.

RECENT TECHNICAL REPORT

CATCHMENT SCALE MODELLING OF RUNOFF, SEDIMENT AND NUTRIENT LOADS FOR THE SOUTH-EAST QUEENSLAND EMSS

by
Francis Chiew
Philip Scanlon
Rob Vertessy
Fred Watson

Report 02/1

In a jointly-funded study, the South East Queensland Regional Water Quality Management Strategy and the CRC developed an Environmental Management Support System (EMSS) to simulate runoff and pollutant movement across the South East Queensland region.

This report summarises a vital part of the research that went into the development of the EMSS. It describes the runoff and pollutant load model used in the EMSS and recommends model parameter values for use in the South East Queensland region.

Copies available through the Centre Office for $27.50.

RECENT TECHNICAL REPORT

ESTIMATION OF POLLUTANT CONCENTRATIONS FOR EMSS MODELLING OF THE SOUTH EAST QUEENSLAND REGION

by
Francis Chiew
Philip Scanlon

Report 02/2

In a jointly-funded study, the South East Queensland Regional Water Quality Management Strategy and the CRC developed an Environmental Management Support System (EMSS) to simulate runoff and pollutant movement across the South East Queensland region.

This report summarises a vital part of the research that went into the development of the EMSS. It recommends appropriate pollutant loading values for adoption in the EMSS. The work reported here is based on a very extensive data-mining exercise where the authors scoured reports and databases compiled by several organisations and scientists. In so doing, they have added significant value to work initiated by others.

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More importantly, most experimental evidence suggests that afforestation can significantly reduce dry-season flow or even dry-up streams completely. Relative reductions in dry-season flow as a result of afforestation are greater than the reductions in storm-flows, although the latter will have much greater impact on total volume reduction.

Modelling flows with changes in land uses

In theory, we can rely on detailed process-based models to predict the seasonal impact of afforestation on flow. In practice, this has proven to be a difficult task due to limited data availability and the competing processes that are not explicitly considered in most hydrologic models. What realistic alternatives do we have? One of the options is to use data from experimental catchments to gain some understanding of how seasonal flows are affected by afforestation. In Project 2.3 we characterised the changes in flow regimes by examining flow duration curves (FDC) under different land-use conditions (eg. trees vs grass). An FDC represents the relationship between the magnitude and frequency of stream flow for a catchment. It provides an estimate of the percentage of the time a given flow was equalled or exceeded.

Pine creek catchment

So what can we learn about the changes in flow regime from the data obtained from experimental catchments? As an example, we used the data from Pine Creek, a tributary of Sunday Creek, within the Goulburn River catchment. The catchment area is 320 ha (3.2 km2) and was open grassland prior to 1987, when the whole catchment was planted to pinus radiata. Flow from the catchment was monitored from 1988 onwards to quantify changes in hydrological process as a result of the tree planting. Figure 2.1 shows daily FDCs at Pine Creek for the periods of 1989-1991 and 1998-2000. We assumed that flow for the period of 1989-1991 represents flow under pre-treatment conditions (i.e. grass) because the trees were very small then. It is clear that the relative reduction is much greater for low flows than for high flows. It should be noted that the FDCs at Pine Creek were affected by both land-use change and rainfall variability. To quantify the impact of land-use change on flows, one needs to remove the effect of rainfall. The method developed by Lane et al. (2002) can potentially be used for this purpose, but it needs further testing.

Simulation for Goulburn-Broken Catchments

We have transferred the FDC results into a simulation of available water in the Goulburn-Broken Catchments. Irrigation customers hold a "water right" that entitles them to two water products. The first part is a minimum volume based on seasonal allocations, and the second part is a "sales" component able to be purchased separately. Using three different sets of conditions, current forests, probable future forest, and maximum forest, the water regime was modelled. Figure 2.2 shows the results, and that the chance of minimum water rights not being met changes from the current 3% to 7% with maximum forest cover. The modelling showed that under the current entitlements and the probable forest scenario, unregulated flows would decrease by an average of 5%. Under the maximum plantation development scenario, unregulated flows would decrease by an average of 22%.

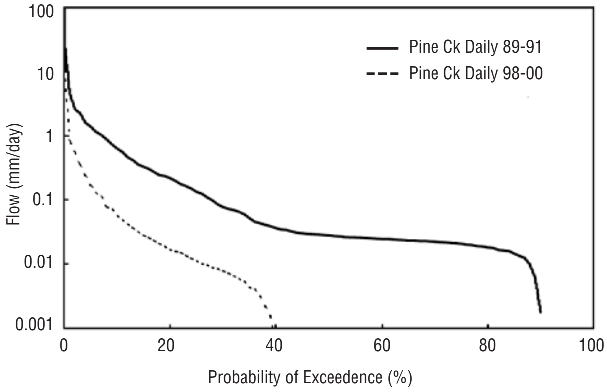

Figure 2.1. Daily flow duration curves for Pine Creek catchment under two different land-use conditions. The solid line represents daily flows under grass and the dotted line represents daily flows under plantation.

Results

It is apparent that both annual flow volume and seasonal patterns are affected by afforestation, and they in turn can have major effects on water supply for users. The results demonstrate the potential uses of predicting changes in river flow regime, but the model is still in its infancy and requires further development.

The CRC for Catchment Hydrology proposed project 2E aims to develop and operational procedures based on this work. It will be developed for inclusion in daily water-balance models such as IQQM and REALM.

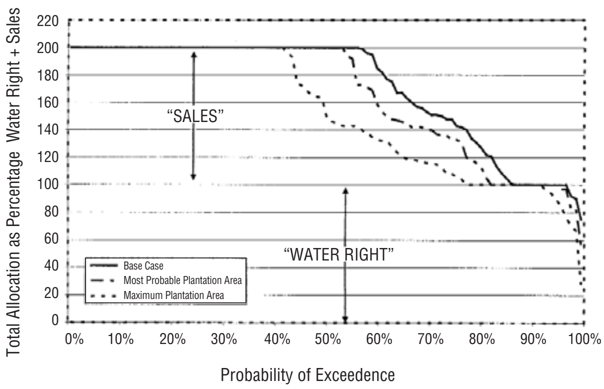

Figure 2.2. The predicted effect of afforestation on reliability of Goulburn system water allocations, estimated using the GSM Bulk Entitlement model.

Reference:

Lane, P., Hickel, K., Zhang, L., Best, A. (in prep.) The effect of plantations on inter-annual stream flow regime. Cooperative Research Centre for Catchment Hydrology Report, in preparation.

Lu Zhang
Tel: (02) 6246 5802
Email: lu.zhang@csiro.au

Warrick Dawes
Tel: (02) 6246 5751
Email: warrick.dawes@csiro.au

Report by Christy Fellows

Distribution of carbon in riparian zone soils

One focus of Project 2.5: 'Nitrogen and carbon dynamics in riparian buffer zones' has been to gain a better understanding of nitrogen transport and transformation in the riparian zone of a small tributary of Coochin Creek in south-east Queensland.

Riparian zones in general are considered to have great potential for supporting denitrification (microbial conversion of nitrate to nitrogen gas) because shallow water tables and saturated, oxygen-deficient soils and sediments often occur in riparian zones. The feature most frequently cited as leading to high rates of denitrification in riparian zones is increased availability of organic carbon due to the presence of riparian vegetation. This organic carbon serves as a potential source of energy for the microbes carrying out denitrification, and so high rates of denitrification are expected to occur where high levels of organic carbon are present in the soil. Describing the distributions of organic carbon could therefore be used to identify locations of potential denitrification.

This approach was taken in a CRC Summer Studentship project undertaken by Josie Carwardine during December 2001 to March 2002. The objectives of the project were to:

1) describe the distribution of soil chemical characteristics, particularly organic carbon and nitrogen, across the site and with depth,
2) compare soil organic carbon and nitrogen content between cultivated fields and within the riparian zone, and
3) investigate the relationship between groundwater and soil chemistry.

Soil Sampling and Chemical Analysis

The Coochin Creek tributary field-site consists of a network of groundwater wells and piezometers covering a field cultivated in pineapples and forested riparian zone. The riparian zone begins at the elevation of the field, and drops about 2 m in elevation over a hillslope to the floodplain where the stream is located. Soil sampling was undertaken at three locations within the study site: within the cultivated field, and within the riparian zone, both on the hillslope and in the floodplain. Soil cores were taken with 10 cm diameter augers by hand or with a Geoprobe intact core sampler (5.4 cm diameter). Soil profile descriptions were undertaken for each core, and this information was used to select depth increments for analysis. Samples were analysed for total organic carbon and total nitrogen, both % by mass, using combustion in a CNS-2000 Leco instrument. Samples for analysis of groundwater chemistry were sampled from wells and piezometers installed in holes left by core removal or in nearby wells. Water levels in these wells were used to determine the maximum and minimum water table elevations over the past year.

Distribution of soil organic carbon

Shallow soil layers had appreciable amounts of organic carbon, especially in the floodplain of the riparian zone (Figure 2.3). Soil nitrogen content directly tracked that of organic carbon, resulting in similar patterns for nitrogen. There were not many significant relationships between soil and groundwater chemistry, with the exception of a strong positive relationship between soil organic carbon and groundwater dissolved organic carbon during a period of high water table elevations.

Figure 2.3 shows the distribution of soil organic carbon with depth for one core from each of three sampling locations as an example of the general patterns observed.

- Cultivated field: low organic carbon overall, with values less than 0.5% except right at the surface; TOC values dropped to near the detection limit (0.1%) by 1-2 m depth; maximum water table elevation was more than 4 m below the surface.
- Riparian zone hillslope: higher organic carbon than cultivated field, but followed similar pattern of dropping to detection limit by 2 m deep; highest water table elevation just reached the bottom of the soil layers with detectable organic carbon.

NEW TECHNICAL REPORT

OPTICAL PROPERTIES OF LEAVES IN THE VISIBLE AND NEAR-INFRARED UNDER BEAM AND DIFFUSE RADIANCE

by
Iain Hume
Tim McVicar
Michael Roderick

Report 02/3

Land-use impacts on the water balance and regional hydrology through vegetation. Agricultural and natural resource managers therefore need to know the amount of understorey and overstorey vegetation in these woodlands. Remote sensing has a role in this assessment.

This report describes laboratory studies to determine if the remote sensing signature of tree and grass leaves differ enough to allow them to be unmixed using broad-band satellite data. Additionally, further understanding of the way understorey and overstorey leaves absorb diffuse and beam light was developed. These results provide an avenue forward for remote sensing in this difficult area.

Copies are available through the Centre Office for $27.50

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

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Contact Virginia Verrelli on:
tel 03 9905 2704
fax 03 9905 5033
email
crcch@eng.monash.edu.au

Centre Office Postal Address:
CRC for Catchment Hydrology
Department of Civil Engineering
PO Box 60 Monash University
Victoria 3800

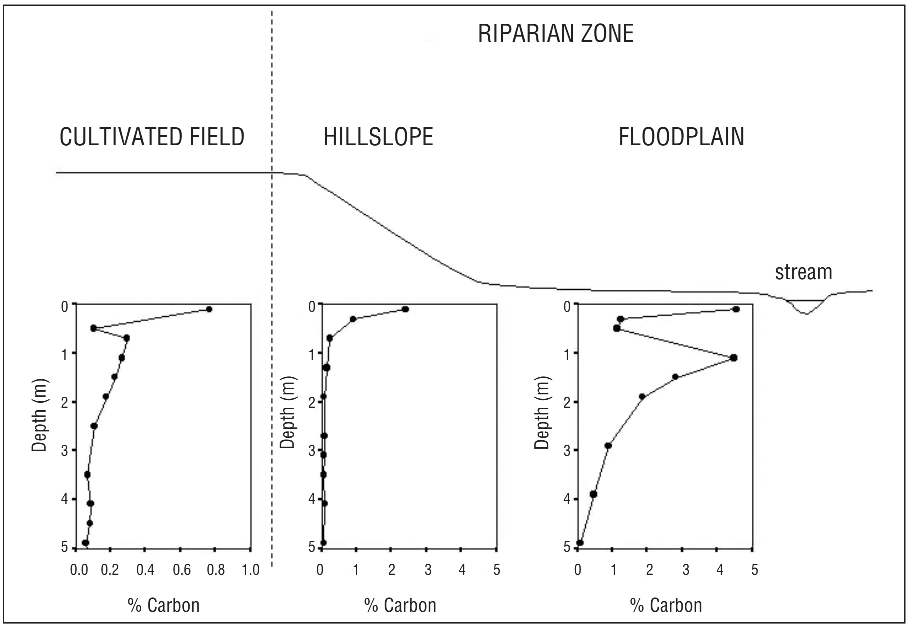


Figure 2.3: Distribution of soil organic carbon (% by mass) with depth at three locations within study site. Locations are represented on a schematic cross section of field site elevation (not to scale).

- Riparian zone floodplain: highest concentration of organic carbon, with concentrations of up to 4% in top 1 m; concentrations decrease with depth after 2 m, but appreciable organic carbon still present to 4 m; water table is consistently within carbon rich soil in this location because the minium water table elevation is 2 m and the maximum is above the surface during elevated stream flows.

Soil organic carbon + shallow groundwater = potential for denitrification

The results of soil organic carbon analyses, coupled with information about maximum and minimum water table elevations, suggest a relatively low potential for denitrification of groundwater nitrate in the pineapple field and riparian zone hillslope, but high potential in the riparian zone floodplain. Additional aspects of site hydrology were presented in the December 2001 and June 2002 *Catchword* articles, including the presence of a permanent water table that is connected to the regional groundwater system, and a local perched water-table that is restricted to the floodplain and develops in response to stream flow. The residence time of groundwater in the shallow perched water-table appears to be on the order of days or longer, and therefore should be long enough to allow for effective removal of groundwater nitrate via denitrification.

Rates of nitrification

After predicting the locations and depths within the field site that could support denitrification, the next step is to measure rates of denitrification. Only a portion of the organic carbon quantified in this study may be available for consumption by microbes, depending on the type of organic compounds that comprise the total organic carbon. The information about the spatial distribution of organic carbon at the field-site has been incorporated into the experimental design of laboratory and field measurements of denitrification. Assessing the actual rates of denitrification in the soil will yield a more direct indicator of the availability of organic matter to the microbial population as well as information about what other factors influence rates of denitrification at the site. Future plans include generalising the results from this field-site to develop a simple model of denitrification processes in riparian zones that can be incorporated into the CRC's Catchment Modelling Toolkit.

Christy Fellows
Tel: (07) 3875 3840
Email: c.fellows@mailbox.gu.edu.au

PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by Avijeet Ramchurn

The role of on-farm storages in modelling the water resources of the Gwydir System

The role of on-farm storages in irrigation areas

With the introduction of the Council of Australian Governments' (COAG) water reforms and the Cap on diversions in the Murray-Darling Basin (MDB), there are strong incentives for the irrigator to make opportunistic use of any available additional water. Rainfall runoff and river-bank overflows during flood events present opportunities to irrigators to harvest free water without licence constraints. Off-allocation water, which comes from high-flow events after environmental needs have been satisfied, is also opportunistically available, but is limited to a proportion of the licence volume of the irrigator. It also has a cost. On-farm storages (OFS) are essential to allow harvesting of water so that the irrigator can use it when the need arises later in the season.

In certain parts of the MDB where resources have been severely over-allocated prior to the introduction of the Cap, such as in the Gwydir catchment, the low probability of being allocated the full entitlement in any given year has forced irrigators since the early 1980's to make use of OFS in the fashion described above. These storages, with capacities sometimes in excess of 20,000ML, play an essential role in ensuring that the irrigators have enough water for the success of their crops. It is important therefore to gain a better understanding of the contribution made by such on-farm storages to farm viability, and to assess likely impacts of OFS development on other parts of the system.

Research focus

Within the broader structure of Project 3.1: 'Integration of water balance, climatic and economic models' this project was aimed at:

1) assessing the sensitivity of the IQQM (Integrated Quality and Quantity Model) outputs to a number of factors related to on-farm storages, including farm-dam characteristics and their model representation, and

2) understanding how OFS's and farm dams contribute to the management of risk related to climatic uncertainty.

Although not a CRC for Catchment Hydrology focus catchment, the Gwydir system was selected for this study because of a high prevalence of OFS and because a calibrated IQQM model of that catchment was available (from DLWC). The total OFS capacity modelled in the catchment is some 351,000ML, while the total of irrigation entitlements exceeds 514,600ML.

This report focuses on one particular aspect, namely, the system sensitivity to increases in OFS capacity. Here, some results relating to the redistribution of water usage on the farm, as well as the potential impacts on the environment, are presented.

Other issues investigated in the research are:

1. The importance of OFS capacity with respect to crop sustainability
2. The efficacy and deficiencies of runoff harvest modelling in IQQM
3. The effect of irrigator's risk-taking in IQQM
4. The importance of OFS in model resolution

Methodology

The IQQM model of the Gwydir system consists of a nodal representation of all the important physical entities of the catchment, such as storages, weirs, towns, groups of farms and wetlands. The operating parameters of each of those entities are also defined at the level of detail required to allow a realistic assessment of the impacts of various management policies or development scenarios to be investigated. Thus, irrigator farms of the Gwydir (mostly cotton farms) are grouped according to location and cropping behaviour into 28 'irrigator' nodes.

The irrigator nodes on which the scenario analysis concentrated (focus nodes) were primarily selected according to location and OFS importance criteria. As the Gwydir River has the peculiarity of branching into four sub-streams (from northernmost to southernmost: Carole Creek, Gwydir River, Mehi River, and Moomin Creek), one node was investigated on each branch and one on the main river prior to the branching, at the top end of the irrigated section of the valley. The selected nodes had to satisfy most or all the following criteria:

a. Ratio of OFS volume/ Entitlement ratio > 0.5

b. Rainfall runoff harvesting capacity > 500ML

c. Variety of crops.

NEW TECHNICAL REPORT

THE DEVELOPMENT OF WATER REFORM IN AUSTRALIA

by

John Tisdell
John Ward
Tony Grudzinski

Report 02/5

The first phase of the CRC Project 3.2 'Enhancement of the Water Market reform Process' was to gather background information on water management in Australia, and water reform and water trading in particular. Part of this important process is to gain an overview of the nature of water, a history of water management in Australia, and current literature on water reform. This report is a summary of that overview and contributes to a greater understanding of water management in Australia and its future.

This report is now available from the Centre Office for $33.00.

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

NEW TECHNICAL REPORT

STOCHASTIC GENERATION OF ANNUAL RAINFALL DATA

By
Ratnasingham Srikanthan
George Kuczera
Mark Thyer
Tom McMahon

Technical Report 02/6

One of the goals of the Climate Variability Program in the CRC for Catchment Hydrology is to provide catchment and river managers, and other researchers in the CRC, with computer programs to generate climate data. The need is for this at time scales from less than one hour to a year, and for point sites through to large catchments like the Murrumbidgee and the Fitzroy. Our first report (CRC Technical Report 00/16) in this series is a comprehensive literature review; in it a number of techniques are recommended for testing.

This is the first of several reports assessing stochastic data generation techniques. It includes tests of several models to generate stochastically annual rainfall data at 44 sites across Australia.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

Table 3.1 Focus node details

River Branch	Node Name	OFS capacity (ML)	Licence volume (ML)	% OFS vs Licence	Runoff harvesting capacity (ML)	Effective No. of crop types
Gwydir Main	IRRGwyd01b	1,750	7,064	25	29	2
Mehi	IRRMehi02	44,700	62,323	72	1,438	3
Moomin	IRRMoom3	28,320	47,892	59	1,216	3
Gwydir	IRRGwyd3b	15,104	19,824	76	717	2
Carole	IRRCar01	43,775	77,587	56	1,661	2
Total		**133,649**	**214,690**	**62**	**5,061**	

As Table 3.1 shows, the only node not satisfying all the criteria is the one upstream of the branching (i.e. Gwydir Main).

At these nodes, scenarios corresponding to 50% and 100% increases in OFS capacity were investigated, corresponding to 19% and 38% increases respectively in the total OFS capacity in the system. In order to reflect different options for providing extra storage capacity (widening or deepening of existing storages), four scenarios were analysed, subsequently referred to as: OFSx1.5 (wider), OFSx2(wider), OFSx1.5(deeper) and OFSx2(deeper).

The benefits and impacts of these scenarios were then measured in terms of the re-distribution of water from different sources at the irrigator node itself, and in terms of the upstream and downstream flow impacts.

Key results

- Water utilisation

Figure 3.1 shows, for the focus node on the Mehi River, how the average utilisation of water sourced from the irrigator's licensed allocation, off-allocation access, floodplain harvest, and runoff harvest changes with different on-farm storage capacities and configurations.

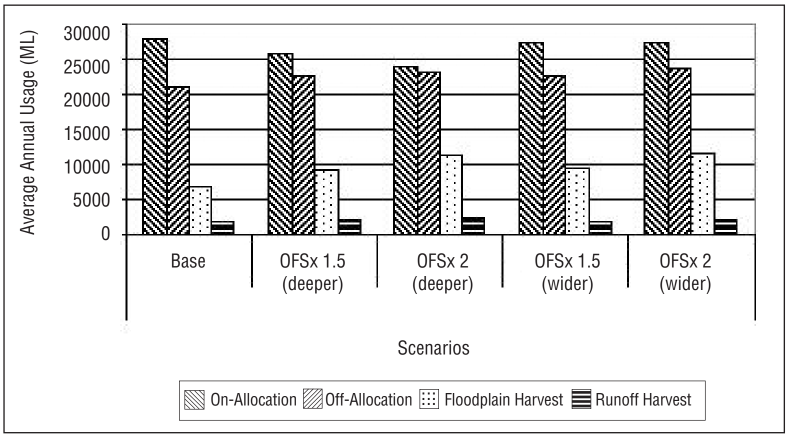


Figure 3.1: Effect of OFS capacity and configuration on water usage from different sources (Mehi River node)

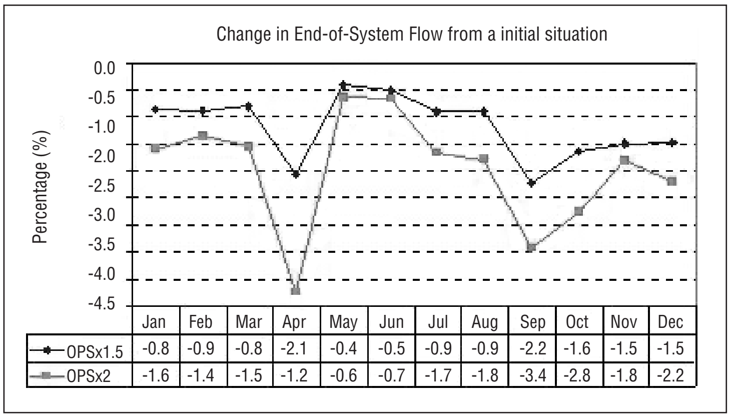


Figure 3.2: Effect of increasing OFS capacity on end-of-system flows in IQQM (OFS wider)

- Effect of larger on-farm storages

Figure 3.1 indicates that the presence of larger on-farm storages in a catchment leads mainly to extra harvesting from floods and off-allocation events, and to a reduction in usage of on-allocation water. Irrigators with larger OFS would be able to either trade saved water from their allocation or irrigate more cropped areas in the next year.

It is also evident that the configuration of the extra storage volume is also very important from a system efficiency point of view. An irrigator is able to save significantly on usage of on-allocation water if the OFS is deepened rather than widened. This is due to large evaporation losses taking place in summer during the irrigation period when the irrigator would be expected to use the on-allocation water.

Figure 3.2 shows the impact of extra OFS, at the focus nodes, on the flows exiting the Gwydir system. As can be seen, an increase in OFS capacity in the system consistently causes reduced outflow as high flows are increasingly captured. Because opportunistic harvesting of high-flow events basically causes this flow reduction, the effects are similar for both wider and deeper storages.

Conclusion

The research on the role of on-farm storages in the Gwydir system has shown that increases in OFS capacity can produce significant benefits at the farm level, if the additional storage volume is provided in a way that minimises additional evaporation. However, even then, the benefits to farmers can only be obtained at a cost in terms of reduced flows in the lower parts of the system.

Acknowledgements

I would like to express my gratitude towards my supervisors, Erwin Weinmann and Gary Codner, and DLWC staff, in particular Marina Sivkova, Rob O'Neill and Geoff Podger, for their assistance during the course of my project.

Avijeet Ramchurn
Tel: (03) 9905 5946
Email: avijeet.ramchurn@eng.monash.edu.au

PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

Report by Sara Lloyd

Strong Community Support for Water Sensitive Urban Design

Background

The emergence of Water Sensitive Urban Design (WSUD) as an urban planning and design philosophy promotes the use of a variety of structural Best Management Practices (BMPs) to collect, treat, store and/or reuse water. Understanding community acceptance and perceptions of these BMPs and other integrated water management schemes will help to enhance their adoption.

The CRC for Catchment Hydrology, in conjunction with the Urban and Regional Land Corporation and Melbourne Water, commissioned a market research project to answer some key questions regarding WSUD and the community. The findings from this project will help facilitate the adoption of WSUD practices into urban design in a manner that the community will embrace, and industry can endorse.

The research sought answers to the following questions:

- How important does the community perceive alternative water management schemes to be?
- Does the community support the integration of a range of structural BMPs, including broader water management schemes into their own neighbourhood?
- What benefits and concerns do the community associate with different approaches to managing urban stormwater?
- Is the community willing to pay an annual fee for the maintenance of sustainable water management schemes?

The quantitative stage of research involved 300 face-to-face interviews with property owners and perspective buyers drawn from greenfield site developments located in Melbourne's major growth corridors. Participants were provided with stimulus material and a list of positive and negative statements to help communicate what was being discussed. Figure 4.1 shows examples of the stimulus material used.

Key research findings

- How important does the community perceive alternative water management schemes to be?

Survey participants were asked to consider how important they feel it is for residential estates to

NEW INDUSTRY REPORT

WATER SENSITIVE URBAN DESIGN: A STORMWATER MANAGEMENT PERSPECTIVE

By
Sara Lloyd
Tony Wong
Chris Chesterfield

Industry Report 02/10

In response to the need for reliable, cost-effective, environmentally-friendly, robust and aesthetically-pleasing stormwater treatment measures, the CRC for Catchment Hydrology undertook research to develop new and existing stormwater quality improvement practices. The integration of these and other water conservation practices into urban design is referred to as Water Sensitive Urban Design (WSUD) and its principles can apply to individual houses and streetscapes or to whole catchments.

Fundamental to successfully applying WSUD principles to urban development is an understanding of the performance capabilities of structural stormwater management strategies, their life cycle costs and market acceptance. This report centres on the design process, construction activities and monitoring of environmental, social and economic performance indicators associated with Lynbrook Estate's Demonstration Project.

This report is available through the Centre Office for $33.00 (includes GST, postage and handling).

CONFERENCE PROCEEDINGS

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

27-29 August 2001

Brisbane, Queensland

Copies of the 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.

Fig 4.1: Examples of the WSUD concept stimulus material used as part of the quantitative stage of the market research.

Concept C: Urban Wetland (with a lake downstream)

- Stormwater collected from streets and houses drains into the local wetland, which filter the stormwater and removes pollutants.
- In doing, so the water entering the downstream lake is cleaner.

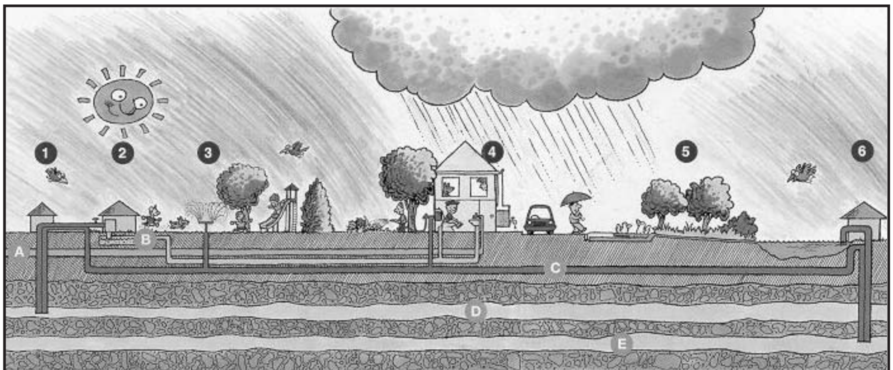
Concept D: Landscaped Swale with Underground Gravel Filled Trench

- A gravel swale (gently dished in shape) with fringing vegetation forms the median strip on main roads.
- Stormwater collected from streets and houses drains into the gravel swale, which filters the stormwater and removes pollutants.
- In doing, so the water entering the downstream waterways is cleaner.
- The same level of flood protection is achieved for these systems as for drainage systems that use standard concrete pipes.

Concept E: Grassed Swale with Underground Gravel Filled Trench

- A grass swale (gently dished in shape) forms the nature strip in local access streets.
- During heavy rains driveways will have an inch of water flowing across them but once it stops raining water on the driveway is quickly removed. Some water will remain in the grass swale for a short period of time after heavy rain.
- The same level of flood protection is achieved for these systems as for drainage systems that use standard concrete pipes.

Concept F: Water Reuse Scheme **(Sourced: Salisbury Council, South Australia)**



1 & 2: Local wastewater treatment plant collects household water and treats it for reuse.
3. Recycled water is used for irrigation of open spaces such as sporting fields, parks and gardens.
4. Recycled water is used for watering household gardens and flushing toilets.
5 & 6. Stormwater is filtered through wetlands and stored for later reuse.

A, B, C, D and E: High quality mains water is used for drinking purposes and treated stormwater and wastewater are stored until required for open space irrigation and household gardens and toilet flushing.

incorporate various water management strategies into their design and the findings are summarised as:

- 96% of respondents believe it is important to treat litter and treat water within the housing estate to minimise pollution (76% believe this strategy to be extremely important)
- 95% of respondents believe it is important to collect and reuse water on residential gardens (69% believe this strategy is extremely important)
- 95% of respondents believe it is important to collect and reuse water on public open spaces (70% believe this strategy is extremely important)
- 77% of respondents believe it is important to treat kitchen and laundry water for household reuse (50% believe this strategy to be extremely important).

- Does the community support the integration of a range of structural BMPs, including broader water management schemes into their own neighbourhood?

Using the stimulus material shown in Figure 4.1 survey participants were asked if they would support the introduction of the WSUD concept into their own housing estate. The results are extremely encouraging and show:

- 95% support for Concept D: landscaped bio-filtration systems forming part of a central median strip (72% strongly supported the introduction of this measure into their estate)
- 95% support for Concept F: a third pipe water reuse scheme (70% strongly supported the introduction of this measure into their estate)
- 93% support for Concept E: grassed bio-filtration systems forming part of the nature strip (62% strongly supported the introduction of this measure into their estate)
- 90% support for Concept C: urban wetland with a downstream lake (66% strongly supported the introduction of this measure into their estate).

- What benefits and concerns do the community associate with different approaches to managing urban stormwater?

Positive and negative perceptions of the four WSUD concepts held by respondents are shown in Figure 4.2 and Figure 4.3 and are summarised as:

- respondents indicate a general lack of understanding of how each WSUD concept works and over 50% felt a public information sign is desirable
- 50-75% of respondents perceive wetlands, vegetated (landscaped) bio-filtration systems and grassed bio-filtration systems as attractive features that could potentially contribute to making an entire housing estate look better and easily blend in with the rest of the area

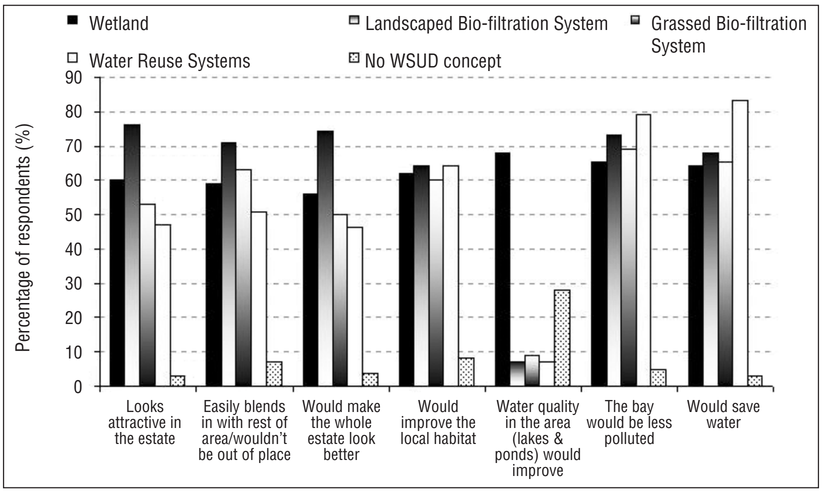


Figure 4.2. Positive perceptions about WSUD concepts

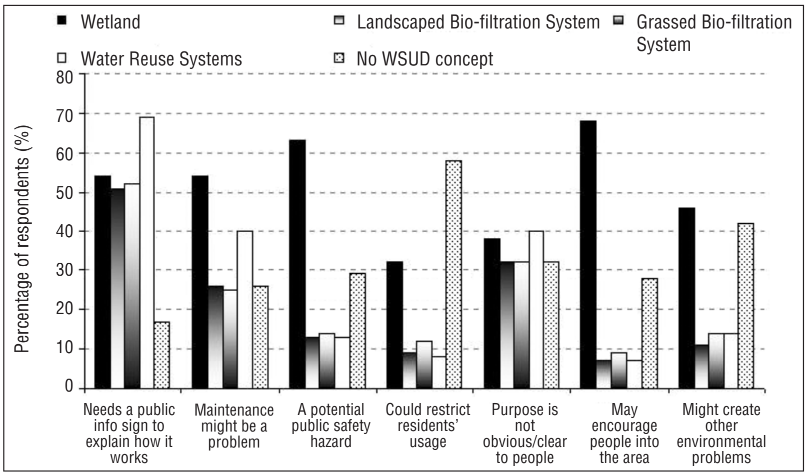


Figure 4.3. Negative perceptions about WSUD concepts

NEW SOFTWARE

MODEL FOR URBAN STORMWATER IMPROVEMENT CONCEPTUALISATION (MUSIC)

MUSIC is a decision-support system. The software enables users to evaluate conceptual designs of stormwater management systems to ensure they are appropriate for their catchments. By simulating the performance of stormwater quality improvement measures, music determines if proposed systems can meet specified water quality objectives.

MUSIC is available from the Centre Office for $88.00

Individuals will need to sign a Licence Agreement (available from the Centre Office and website: www.catchment.crc.org.au)

For further information contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au

Please note: MUSIC version 1.00 is a development version and will be valid until June 2003. The CRC for Catchment Hydrology is committed to updating MUSIC annually until at least 2006. Subsequent versions of MUSIC may be charged for.

OTHER OUTLETS FOR CRC PUBLICATIONS

In addition to the Centre Office, all CRC publications are available through the Australian Water Association (AWA) Bookshop in Sydney and the NRE Information Centre in Melbourne. They also stock a wide range of other environmental publications.

AWA Bookshop (virtual)
contact Diane Wiesner
Bookshop Manager
tel: 02 9413 1288
fax: 02 9413 1047
email: bookshop@awa.asn.au
web: www.awa.asn.au/bookshop/

NRE Information Centre
8 Nicholson Street (cnr Victoria Parade)
PO Box 500
East Melbourne
Victoria 3002 Australia
publication.sales@nre.vic.gov.au
Phone: 03 9637 8325
Fax: 03 9637 8150
www.nre.vic.gov.au
Open: 8.30-5.30, Monday to Friday

- over 60% of respondents believed the four WSUD would improve the local habitat, save water, and that Port Phillip Bay would be less polluted
- two thirds of respondents acknowledge wetlands improve water quality in local waterbodies such as lakes, but less than 10% perceive bio-filtration systems as a mean to improve local water quality
- over 50% of respondents saw wetlands as potentially encouraging pests into the area, as being a potential safety hazard and are concerned over maintenance issues.

These findings suggest there is an opportunity for disseminating information on how WSUD concepts work to lessen concerns held by the community. Education programs could also be directed at enhancing community understanding of the linkages between the application of WSUD concepts and improved local water quality. In turn this would contribute to improved aesthetic and recreational opportunities within residents own housing estates.

- Is the community willing to pay an annual fee for the maintenance of water management schemes?
Strong community support for the introduction of WSUD concepts into residential estates is reinforced by the willingness of respondents to pay an annual fee for the maintenance of BMPs or water management schemes. 59% of respondents would definitely pay, or probably pay, an annual fee and considered the following contributions as reasonable:

- $25 30%
- up to $50 31%
- $50-$100 25%
- more than $100 11%

Summary
Community support for the introduction of WSUD concepts into greenfield site developments is remarkably high. Both current residents and perspective buyers find the aesthetic values and water saving benefits associated with WSUD concepts as highly desirable.

Support extends from WSUD concepts adopted at the allotment scale to those implemented at the streetscape or regional scale. This strong level of support for the implementation of WSUD concepts is reinforced by the willingness of respondents to pay an annual fee for the upkeep of the water management schemes. On-site education materials explaining the function of WSUD elements should enhance community understanding of the role of WSUD.

Sara Lloyd
Tel: (03) 9905 3837
Email: sara.lloyd@eng.monash.edu.au

PROGRAM 5
CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Report by Neil Viney, Stephen Charles and Bryson Bates

Stochastic downscaling of rainfall occurrence in the Murrumbidgee Basin

Introduction
The downscaling component of Program 5.2 ''Modelling and forecasting hydroclimate variables in space and time'' aims to apply a non-homogeneous hidden Markov model (NHMM) to about thirty sites in the Murrumbidgee Basin and to provide an ensemble of climate scenarios that can be used to drive long-term analyses of the water resources system. This will enable an assessment of the reliability and resilience of the basin's water supply system under multidecadal climate variability. The work will also have applications in medium-term forecasting, climate change scenario analysis and regional-scale forensic climatology. In the June 2001 issue of Catchword, we outlined the rationale behind downscaling and gave an introduction to the NHMM. In this article we report on the results of the downscaling of rainfall occurrence across the basin.

The non-homogeneous hidden Markov model
The NHMM relates synoptic-scale atmospheric circulation variables through a finite number of unobserved weather states to multi-site, daily precipitation occurrence data. It finds the most distinct patterns in the daily multi-site precipitation occurrence record rather than patterns in atmospheric circulation. These patterns are then defined as conditionally dependent on a set of atmospheric predictor variables. These atmospheric predictors may include raw variables such as mean sea level pressure (MSLP) or derived variables such as the north-south MSLP gradient. A first-order Markov process defines the daily transitions from one weather state to another. Unlike downscaling techniques that are based on classification schemes, the weather states are not defined a priori.

Within the NHMM, the joint distribution of daily precipitation amounts at multiple sites is evaluated through the specification of conditional distributions for each site. The conditional distributions consist of regressions of transformed amounts at a given site on precipitation occurrence at neighbouring sites within a set radius. The optimal neighbourhood radius is determined by steadily increasing its size until further increases result in only marginal improvements in the proportion of total precipitation variability explained by the precipitation occurrence at neighbouring sites.

Among the advantages of the NHMM approach over other downscaling techniques are that the spatial coherence of the daily rainfall patterns are maintained together with the site-specific temporal patterns (wet and dry spell lengths). Secondly, the model itself selects an optimal set of weather states, rather than depending on a set of predetermined, intuitive states. Thirdly, the ability to classify days into states that are distinct in terms of precipitation as well as synoptic situation means that the realism of the states is directly interpretable in terms of regional hydroclimatology.

Selection of rainfall stations

The first step in applying the NHMM to the Murrumbidgee basin was to select a set of rainfall stations. For computational reasons the maximum number of stations is limited to about thirty. Obviously, we want these thirty stations to be spread as widely as possible across the catchment. To facilitate straightforward coupling with the IQQM model of the New South Wales Department of Land and Water Conservation, it is also desirable that the selected stations coincide as closely as possible to those used in IQQM. Unfortunately, this was not always achievable, since several of the stations in IQQM contained long periods of missing data. For IQQM itself, this is not a problem because in most circumstances, data interpolated from nearby stations will suffice for gap-filling. However, there is potential for biases to develop in the spatial coherence of the downscaled data set when such stations are used with the NHMM. For this reason, eleven of the twenty IQQM rainfall stations were rejected and replaced with nine nearby stations from the Bureau of Meteorology's network. A further twelve Bureau stations were chosen to complement these stations and to fill spatial gaps in the station distribution, especially in the upper catchment where IQQM is not applicable.

Application of the NHMM to the Murrumbidgee Basin

The ten-year period from 1958 to 1967 was identified as the period with the most reliable rainfall data, and was thus chosen for fitting of the NHMM. Fitting is on a seasonal basis, with separate fits for winter (April-September) and summer (October-March). The fitted models have been driven with atmospheric predictors for the 1958-2000 period, with data from 1968 to 2000 being used for out-of-sample validation. All atmospheric predictors are taken from the NCEP-NCAR Reanalysis dataset, a globally and temporally consistent observational record commonly used to validate global climate models.

From the multitude of atmospheric predictor variables available, winter precipitation patterns were found to be most responsive to sea level pressure, the 850 hPa dew point temperature depression and the east-west gradient in 500 hPa geopotential height. The corresponding variables for summer were the east-west gradient in 850 hPa geopotential height and a variable called "total totals" which is the sum of two terms: the difference between the 850 hPa dew point temperature and the 500 hPa air temperature, and the difference between the 850 hPa air temperature and the 500 hPa air temperature. For both models, two additional variables based on the first and second canonical correlation variates obtained from a NHMM using the two (summer) or three (winter) primary predictors and up to 17 other potential predictors were also required.

Results

For both summer and winter, the optimum model resolved six weather states with distinctive patterns of weather occurrence. Validation (not shown here) against the 1968-2000 Re-analysis data indicates satisfactory predictions of rainfall probability and wet and dry spell lengths for all stations.

Each weather state may be associated with a unique spatial pattern of rainfall probability. Examples of three of the winter states are shown in Figure 5.1. State 1 is characterised by a low probability of precipitation at all 30 stations and occurs on 42% of days in the period 1958-2000. In contrast, state 3 (12% of days) exhibits moderately high probabilities in the east grading to low probability in the west, and state 6 (13% of days) involves a high rainfall probability across the catchment. The corresponding event-averaged surface synoptic conditions are shown in Figure 5.2. State 1 is typically associated with an anticyclone over the catchment, state 3 with an approaching mid-winter anticyclone generating strong southwesterly winds, and state 6 with a cyclone to the south and strong westerly winds. State 6 also often coincides with a cold frontal band extending across southern New South Wales.

When we study year-to-year variations in the occurrence of each state, some interesting patterns emerge. Figure 5.3 shows that there is substantial interannual variability in the occurrence of each state. However, long-term trends suggest that state 1 has become more frequent over the past 25 years, while state 3 has declined throughout the period and state 6 declined steadily from 1958 to the mid-1980s, but has recovered slightly since.

NEW TECHNICAL REPORT

ON THE CALIBRATION OF AUSTRALIAN WEATHER RADARS

by

Alan Seed
Lionel Siriwardena
Xudong Sun
Phillip Jordan
Jim Elliott

Technical Report 02/7

Weather radar offers an enormous potential to improve the quality of rainfall measurement. This potential can translate into benefits in many sectors of the water industry ranging from improved design information, decisions on water allocation and management, through to improved weather and flood forecasts for greater public safety.

A key step in transforming weather radar observations into accurate rainfall estimates however is the calibration of the weather radar data. This involves converting the quantity actually observed by the radar (known as reflectivity) into an estimate of rainfall intensity. The current approach used widely with Australian weather radars is to rely on a set of calibration factors that represent average, or climatological, conditions. This can lead to quite large errors in rainfall estimates.

This report describes investigations to improve the calibration process for weather radars in Melbourne, Sydney and Darwin. Rain gauge data has been used to analyse the likely errors in rainfall estimates from radar and calibration strategies to improve the quality of the radar rainfall estimates are proposed.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

UPDATED EVAPOTRANSPIRATION AND RAINFALL MAPS FOR AUSTRALIA

Where to get them!

The CRC for Catchment Hydrology and the Bureau of Meteorology have recently completed a project to produce national maps of evapotranspiration for Australia.

The map set is now available for $33 plus postage and packaging.

They can be purchased from:

1. Publications Section, Bureau of Meteorology, 9th floor, 150 Lonsdale St Melbourne. tel: 03 9669 4000 main switch) and ask for Publications

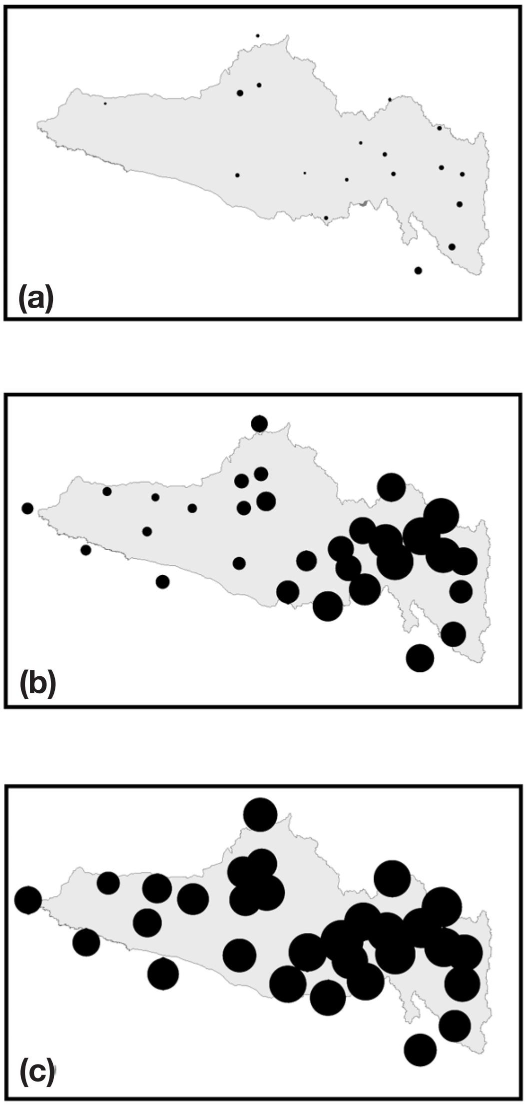
OR

2. Bureau Regional Offices (all capital cities) Contact details for each Regional Office are available at http://www.bom.gov.au/inside/contacts.shtml

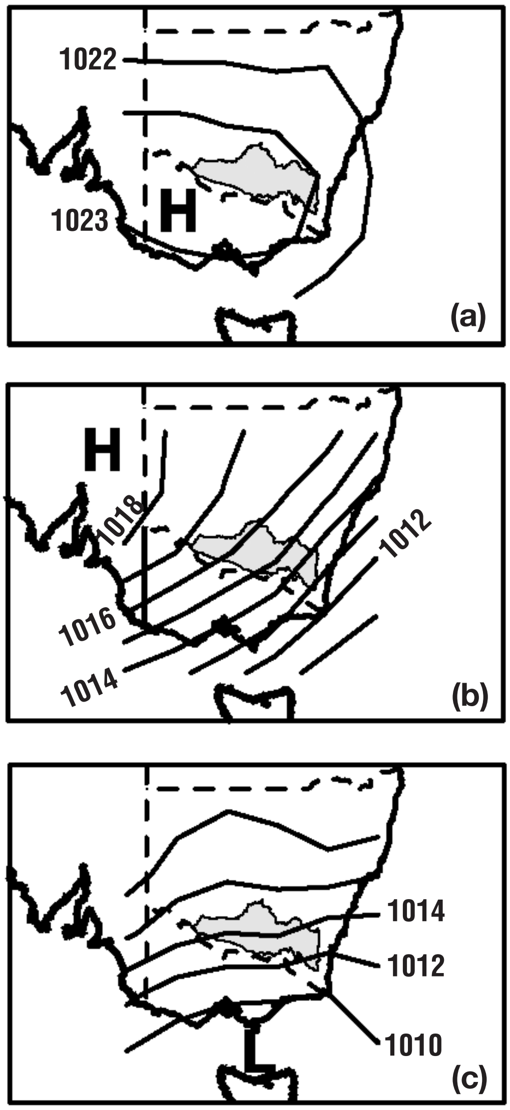
Information about the climate atlas map sets and the digital map data sets can also be obtained from: National Climate Centre Ph: 03 9669 4082 Email: webclim@bom.gov.au

Technical queries about the evapotranspiration modelling can be referred to Dr Francis Chiew at The University of Melbourne email f.chiew@civag.unimelb.edu.au

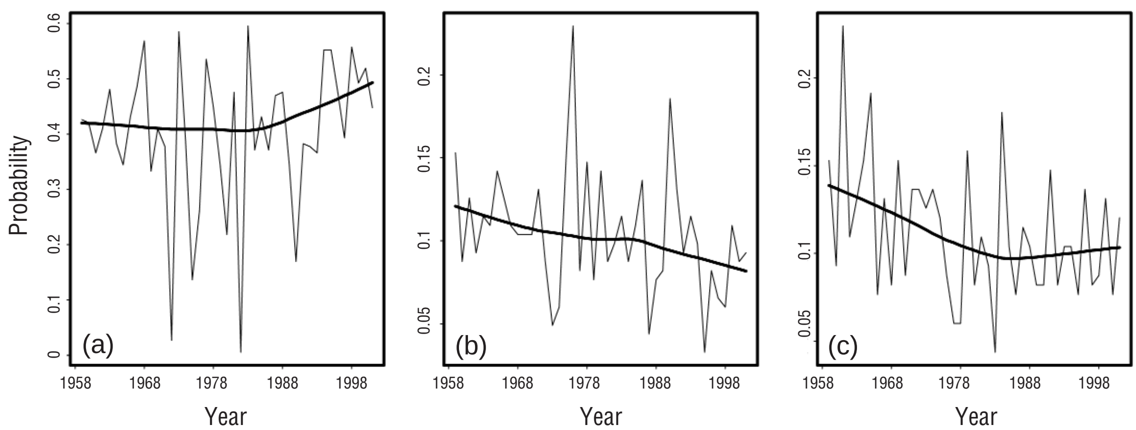
Any technical queries about the mapping should be referred to Graham de Hoedt tel 03 9669 4084 email: g.dehoedt@bom.gov.au



5.1 The Murrumbidgee River basin showing winter precipitation occurrence patterns at the 30 sites in and near the basin for (a) state 1, (b) state 3, and (c) state 6. Occurrence is proportional circle diameter.



5.2 Composite mean sea level pressure fields of winter weather states for (a) state 1, (b) state 3, and (c) state 6. Pressures are in hectopascals.



5.3 Inter-annual variability (thin line) and long-term trends (thick line) of the frequency of winter weather states for (a) state 1, (b) state 3, and (c) state 6.

These trends (increasing occurrence of dry days and decreasing occurrence of wet days) are indicative of a general reduction in rain day occurrence in winter over the Murrumbidgee basin during the last 40 years.

It is hoped that further analysis of the weather states, their transition probabilities, and their intra-seasonal distributions, might shed some light on the mechanisms that are responsible for such a decline.

Further work

Work is continuing on generating multiple sequences of meteorological data for each of the 30 stations. This data will include daily rainfall, solar radiation, temperature and potential evaporation. It will be driven by data obtained from the global climate model, CSIRO Mk3 GCM, to generate 30-year sequences of current and future (say 2041-2070) climate, and will enable analysis of long-term variability of meteorological and hydrological responses in each scenario. The downscaling technique is also readily applicable to medium-term (3-12 months) GCM predictions to provide multi-site seasonal forecasts of rainfall, streamflow and irrigation scheduling.

Neil Viney
Tel: (08) 9333 6342
Email: neil.viney@csiro.au

Stephen Charles
Tel: (08) 9333 6342
Email: stephen.charles@csiro.au

Bryson Bates
Tel: (08) 9333 6342
Email: bryson.bates@csiro.au

NEW TECHNICAL REPORT

STOCHASTIC GENERATION OF MONTHLY RAINFALL DATA

by
Ratnasingham Srikanthan
Tom McMahon
Ashish Sharma

Technical Report 02/8

One of the goals of the Climate Variability Program in the CRC for Catchment Hydrology is to provide water managers and researchers with computer programs to generate stochastic climate data. The stochastic data are needed at time scales from less than one hour to a year and for point sites to large catchments like the Murrumbidgee and Fitzroy.

The first report in this series, 'Stochastic Generation of Climate Data: A Review' (CRC Technical Report 00/16), reviewed methods of stochastic generation of climate data and recommended the testing of a number of techniques. The second report, Stochastic Generation of Annual Rainfall Data' (CRC Technical Report 02/6), compared the first order autoregressive and hidden state Markov models for the generation of annual rainfall data. This third report, 'Stochastic Generation of Monthly rainfall Data', tests the method of fragments and a nonparametric model for the generation of monthly rainfall data at ten sites across Australia.

Copies of this report are available through the Centre Office for $27.50 (includes GST, postage and handling).

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PROGRAM 6

RIVER RESTORATION

Program Leader
MIKE STEWARDSON

Assessing Environmental Flow Requirements Using the Using the Flow Events Method

Introduction

The primary outcome of Project 6.7 'Developing an improved method for designing and optimising environmental flow' is a new tool for evaluating environmental flow requirements of streams called The Flow Events Method. It is intended to support the existing environmental flow methods currently used throughout Australia and focuses on all aspects of the flow regime including low, medium and high flows.

Evolving approaches

Since the early 1980's there has been considerable effort to develop methods for evaluating the environmental flow requirements of Australian streams. Earlier methods focussed on proving minimum flows to protect fish habitat. More recently, it is expected that environmental flows should protect the natural variability in flow regime as well as maintaining minimum flows... but what variability is really important for protecting aquatic communities and natural processes? Is it the year to year variations, the seasonal patterns, or variations associated with individual storm events that are important? How do we trade off loss of natural variability against competing demands from water users and how do we make best use of the available water for environmental flows? The Flow Events Methods has been developed to help resource managers answer these questions.

Steps in flow events method

There are five steps to the Flow Events Method, which can be informed by reference to literature or expert knowledge. For larger projects, an expert panel may be formed to provide input to the process at particular stages and particularly the first two. Here is a very brief overview of the method. Several papers have been written about the method and we are currently writing a user-guide for distribution.

- Step1. List Ecological Factors

Variation in stream discharge affects a wide range of ecological processes within rivers. These affects are the generally thought to be the result of five physical processes:

- drying
- light attenuation
- mixing and advection of dissolved gases and solutes
- transport of inorganic sediments and organic matter
- direct effects on organisms, including drag and abrasion.

The ecological processes of interest will vary between and along streams. The first stage of the Flow Events Method is to decide on the key ecological factors for the study. In a trial application in the lower Snowy River, we choose three factors:

- drying of the stream bed,
- mobilization of bed sediments and bedform development, and
- floodplain processes triggered by overbank flows.

- Step 2. Define Flow Events

The next step is to select a method of characterising individual events and their distribution in time. The flow events are evaluated using hydraulic parameters that measure the severity of the event. For example, drying of the streambed can be characterised by the area of the stream bed that becomes dry.

- Step 3. Model Hydraulic Relations

Once the flow events have been defined, relations between the hydraulic parameters and discharge are derived using hydraulic surveys and modelling. Modelling and survey techniques will vary with expertise and the needs of the project but surveys will generally consist of several reaches that represent variations along the river of interest and a one-dimensional model such as HEC RAS is usually adequate.

- Step 4. Evaluate Flow Management Scenarios

To examine how flow events are affected under different flow management scenarios we can compare the frequency of events with and without the effects of regulation. For the example of bed drying in the lower Snowy River (refer to figure 6.1), we found that on average, before the river was regulated, the bed was exposed only once per year and every 10 years. Particularly low flow events would result in drying of 40% of the stream bed. Since regulation, the bed has been dry on average, three times per year and more than 40% of the bed is dried every two years. Ecologists familiar with benthic fauna can provide advice on the likely biological consequences of this change.

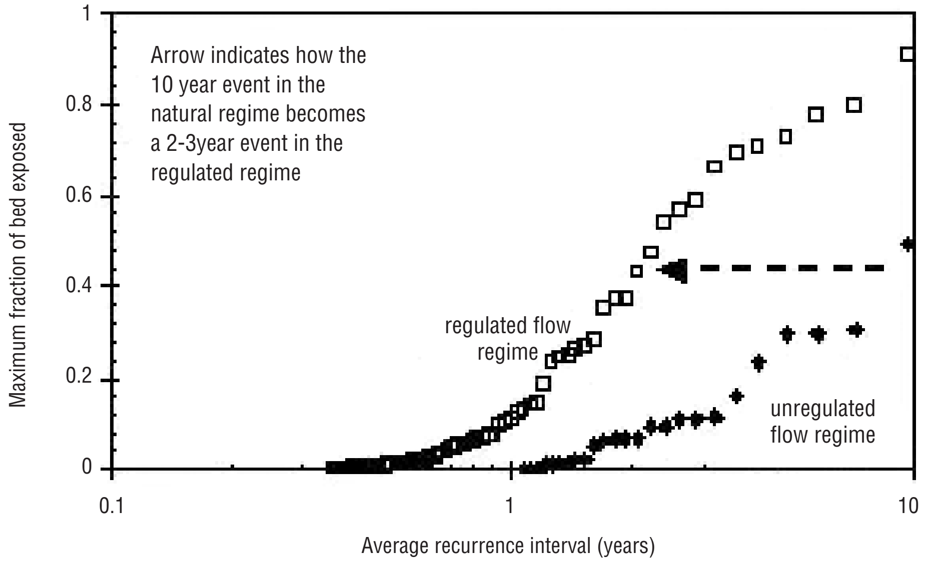

Figure: 6.1 Frequency of events during which, the lower Snowy River becomes dry with and without the effects of flow regulation.

- Step 5. Recommend Environmental Flow Rules or Targets

With advice from experts, it is possible to set environmental flow targets and rules to restrict the changes in the frequency of flow events to acceptable levels. It is also possible to use the method to evaluate alternative flow management scenarios and examine the effect of incremental changes in flow management decisions.

Where to from here?

We have refined the approach in trials on the Broken and Loddon Rivers, working with CRC for Freshwater Ecology, Department of Natural Resources and Environment (DNRE), Goulburn-Murray Water, and the North Central Catchment Management Authority. In both cases, the method was used to support the deliberations of an expert panel and feedback on the approach from both panels was very positive. Terry Hillman, the then director of the Murray-Darling Freshwater Research Centre and panel member for the Broken River said "The Flow Events Method,... every environmental flow study needs one". The recommendations for the Broken River have largely been accepted. It was reported back to me that a particular strength of the method was that it pin-pointed the ecological responses expected as a result of providing environmental flows, rather than referring to generic ecological health improvements. This provided greater transparency for agency staff, irrigators and other members of the community involved in the water allocation process. Following the successful application of the method in the Loddon River, DNRE is looking at ways to incorporate the method into the state-wide framework for determining environmental flows.

Wider distribution of FEM approach

We are now ready to build a user-friendly interface for the Flow Events Method for wider distribution. This will be in the form of a computer program, a guidebook, and possibly documentation of case studies. We will be seeking advice from consultants and key agency personnel to make sure these products are consistent with the expertise of groups undertaking environmental flow studies and support existing environmental flow procedures throughout Australia. If you have an interest in this process and would like to be informed of progress, please send me an email.

Mike Stewardson
Tel: (03) 8344 7733
Email: mjstew@unimelb.edu.au

WORKING DOCUMENT

APPLICATION OF HIDDEN STATE MARKOV MODEL TO AUSTRALIAN ANNUAL RAINFALL DATA

by
Ratnasingham Srikanthan
Mark Thyer
George Kuczera
Tom McMahon

Working Document 02/4

In the past, the stochastic generation of annual data was performed generally with a first order autoregressive model which does not explicitly model the observed long periods of wet and dry periods in the annual data. Though geographers and geomorphologists have observed long cycles or changes in the mean level of rainfall and streamflow, it was not explicitly included in annual stochastic data models until the recent work of Thyer and Kuczera (1999, 2000). The model used is referred to as the hidden state Markov (HSM) model.

The purpose of this study is to apply the HSM model to annual rainfall data from a number of rainfall sites across Australia and identify the the sites where a two-state persistence structure was likely to exist.

Copies are available through the Centre Office for $22.00.

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PROGRAM 7

COMMUNICATION AND ADOPTION PROGRAM

Program Leader
DAVID PERRY

The Flow on Effect - September 2002

At a glance - a summary of this article

In parallel with the planning and development of the second round of CRC research projects, the CRC is also preparing a number of 'development projects'. Development projects aim to promote a more collaborative approach to the development and application of centre products to suitable land and water management issues in our focus catchments.

Introduction

Regular readers of *Catchword* may recall the June 2002 article in this column entitled "Adoption gaps - the transition of research outputs to operational products". The article outlined the advantages that CRC's have in bridging gaps in the delivery of research outcomes through collaboration between industry and research groups. MUSIC (Model for Urban Stormwater Improvement Conceptualisation) was used as an example of how the CRC Parties can join forces to better meet industry needs in a shorter time. This principle is now being formalised by the CRC as part of the planning for the second round of projects (2003-2006).

Adoption a priority

The CRC's Business Plan (1999-2006) clearly states that the prime measure of CRC performance is the level of adoption of the Centre's products by land and water managers. For the CRC to achieve a high level of adoption, processes for communication and adoption must relate to the organisational environments of such managers. There is also a need to be able to assist research teams and user organisations to interact more effectively.

By the end of 2002, and progressively beyond that, the Centre will produce a number of products of immediate use to catchment land and water managers. To ensure that the CRC achieves a high level of adoption, it is important that this knowledge and capability be made use of as soon as it is available, rather than wait for the more complete 'toolkit' envisaged by the second round of projects (detailed in earlier editions of *Catchword*.)

Development projects

For some months, regular discussions have been held in the CRC with the specific aim of improving our collaborative approach to the development and application of Centre Products to suitable land and water management issues in our focus catchments. This has resulted in the concept of 'development projects', originally proposed by Peter Hairsine.

Development projects are designed to facilitate collaborative development and ensure the early application of (and feedback on) Centre products. They will focus on the transition from research products to operational products.

In May this year, the CRC Board supported a proposal to establish a number of development projects in parallel with planning for the Second Round of core projects.

Key features of development projects

Features of development projects include:

- They will be based in the CRC's focus catchments with an activity that demonstrates and enables integrated research and development products in that catchment. They will be sharply focused, and run for three years.
- A substantial proportion of project activity will be spent further developing software products suitable for use at a catchment scale (for example the Environmental Management Support System (EMSS), MUSIC and SEDNET)
- A catchment-based person (the 'Development Project Coordinator') will be responsible for liaising with researchers and catchment stakeholders on the future development of CRC tools, assembling relevant catchment data for the software, and demonstrating software in conjunction with the local agencies.
- CRC researchers will support the projects with planned training through the Development Project Coordinator, and assisting industry staff in running applications of software models.
- They will be largely funded by CRC in-kind resources. There are also opportunities to fund part of these projects from external sources (for example, national programs or regional agency initiatives)
- They will be a major vehicle for communication, development and adoption of CRC products and will form the foundation for the CRC's post-2006 planning.

Focus catchment coordinators

Our Focus Catchment Coordinators (FCCs) are playing a major role in formulating the development projects for their catchment with support from relevant organisations Program Leaders and myself. Projects are being drafted which address a key catchment issue based on the application of relevant CRC research products. To date, development projects for the Yarra, Goulburn-Broken and Murrumbidgee focus catchments have been drafted. Planning for the Brisbane and Fitzroy catchments has also commenced.

Key component of our adoption strategy

Development projects are an excellent opportunity to utilise and improve the modelling capability of research and user organisations. They also focus efforts on the application of the CRC's research outcomes to a specific integrated and catchment scale problems. Details of the development projects and their progress will feature in future issues of *Catchword*.

For further information about development projects speak to the relevant Focus Catchment Coordinator. Their details are available at www.catchment.crc.org.au/contact or you are welcome to contact me directly on the number below.

David Perry
Communication and Adoption Program
Tel: 03 9905 9600
Fax: 03 9905 5033
email: david.perry@eng.monash.edu.au

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

NEW WORKING DOCUMENT

STOCHASTIC MODELLING OF DAILY RAINFALL

by
Senlin Zhou
Ratnasingham Srikanthan
Tom McMahon

Working Document 02/5

Stochastic generation of rainfall data offers an alternative to the use of observed records. This paper presents an evaluation of daily rainfall generation models at 21 stations across Australia. The models are the Transition Probability Matrix (TPM) method, the Daily and Monthly Mixed (DMM) algorithm, and a variation of each model.

A goal of stochastic modelling is to generate synthetic data that are representative of the statistical characteristics of the historical data. One hundred replicates of length equal to the historical data were generated using the above models. Preliminary assessment of the models suggests that overall both the TPM and DMM models preserved key statistical characteristics of the historical rainfall at the annual, monthly and daily levels. The DMM model was unable to preserve the amounts of rainfall on solitary wet days and the TPM model needed to be modified by the empirical adjustment factor to preserve the annual variability.

Copies of this report are available through the Centre Office for $22.00 (includes GST, postage and handling).

POSTGRADUATES AND THEIR PROJECTS

Geoff Taylor

Background

My interest in land management and natural resource issues stems from my early adolescence when I developed a love of nature and an affinity for the ecology of our country. To further confirm that a career in an environmentally related occupation was the right choice, I applied (and fortunately was selected) to attend the 1996 National Youth Science Forum in Canberra. This was a significant turning point in my life and gave me the opportunity to meet Australia's leading scientists and discuss issues relating to chemical, physical and biological science at a national level. This invaluable experience inspired me to study a tertiary course that put environmental issues in a scientific context.

I graduated from the Royal Melbourne Institute of Technology's (RMIT) Environmental Science Faculty, attaining my degree in 1999. In addition to completing this degree, I furthered my studies by obtaining first class honours in 2000, investigating the significance of nutrient enrichment in the Latrobe River from the Macalister Irrigation District.

Prior to starting as a postgraduate with the CRC for Catchment Hydrology, I spent seven months training as an Environmental Scientist for Agriculture Victoria in the Water and Soils division at Ellinbank, Victoria.

My interest in postgraduate study of stormwater in urban catchments originated from my interest in environmental issues. Particular interests are the physical, chemical and biological impacts that urbanisation places on urban aquatic ecosystems and receiving waterways.

A driving force for my interests is a concern about human interactions, such as management strategies, on receiving waterways. We humans develop systems based on worldwide views that guide the economics and political agenda, which in turn influence our society's values. However, from an environmental perspective, these systems are not always as suited to one part of the world as another. As a result, these systems may remain sustainable for a short time only before declining in stability.

Research topic

My Research Topic is: Nitrogen Composition in Urban Stormwater Runoff Prior to Entering Constructed Stormwater Treatment Wetlands

- Introduction

The composition of nitrogen in urban stormwater runoff exhibits characteristics that depend on various time-scales, storm events and dry weather operations. Nitrogen compounds in storm runoff are often traced back to the build-up of pollutants in a catchment during dry weather periods, and to deposits of nitrogen as a result of atmospheric fall-out and precipitation.

The design of wetland systems to treat urban stormwater runoff requires a sound knowledge of the chemical characteristics of stormwater prior to its entering a treatment wetland.

Treatment processes in constructed stormwater wetlands include physical, biological and chemical functions operating under highly dynamic hydrologic and hydraulic conditions. Depending on the proportion and composition of nitrogen compounds entering stormwater treatment wetlands from urban catchments, various treatment processes will occur during wet and dry weather.

Success with wetland design is also assisted by being able to predict the behavioural patterns of different nitrogenous compounds based on changes in the water and soil chemistry of constructed stormwater wetlands. These changes include pH, temperature and redox properties.

- Objectives

To date, the objectives of my PhD candidature are:

- To determine the composition of nitrogen in urban stormwater runoff.
- To identify nitrogen transformation and removal processes in constructed stormwater treatment wetlands, particularly nitrogen transformation and removal during storm and dry weather operation.
- To identify the proportions of particulate and soluble organic nitrogen compounds present in stormwater runoff, and to track the fate of these nitrogen compounds in stormwater treatment wetlands.

An understanding of the various processes affecting the removal and transformation of nutrients in constructed stormwater wetlands operating under a variety of conditions is required. To date, the primary focus in the design objectives of stormwater treatment wetlands has been the provision of the physical operating conditions that are conducive to the removal of fine particulates during storm inflow conditions. It is envisaged that improved design features can be incorporated into stormwater treatment wetlands for improved nutrient removal on a storm event and inter-event basis. To achieve this objective, it will be necessary to gain a better insight into the various processes, other than the physical removal of fine particulates, that are effective in removing and transforming nutrients in stormwater treatment wetlands.

- Research to Date

To date, preliminary experiments have been conducted to investigate the chemical composition of nitrogen compounds in urban runoff. Composite samples have been collected from numerous storm events. The chemical characteristics of the samples have been compared to a literature review data set to identify if a significant correlation exists between urban runoff and the fraction of each nitrogen compound present in urban runoff. Results from this experiment suggest that components that constitute Total Nitrogen in urban runoff exhibit similar percentages from multiple sources, even when the concentrations vary from different sites.

To determine if there is any change in the chemical composition of nitrogen via composite sampling over time, a preliminary sampling experiment has been conducted. This preliminary experiment was conducted at Ruffeys Creek Wetland, Melbourne, where six replicate sample sets were taken from a storm event and tested for nitrogen compounds including: total nitrogen, organic nitrogen, nitrate and nitrite (defined as NOx), ammonia, dissolved organic nitrogen, total dissolved nitrogen and particulate organic nitrogen. Suspended solids were also analysed.

Results obtained from this experiment indicate that obtaining a composite sample within 30 hours after a storm event will be representative of each nitrogen compound. This suggested that over a 30 hour range, the transformation of a nitrogen compound into a different nitrogen compound is negligible.

- Future work:

The target outcome of this research is a design for constructed stormwater treatment wetlands which will enhance nitrogen transformation and removal without causing any adverse effects on the many pollutant treatment processes in wetlands

It is envisaged that future experiments will involve developing some innovative designs that will combine some of the multiple treatment processes which apply in constructed stormwater treatment wetlands.

Geoff Taylor
Tel: (03) 9905 5578
Email: geoff.d.taylor@eng.monash.edu.au

2002 CRC VACATION STUDENTSHIPS

VARIOUS LOCATIONS AROUND AUSTRALIA $400 PER WEEK FOR 8-12 WEEKS (DURING DECEMBER TO FEBRUARY)

Studentships to participate in land and water management research projects are being offered by the CRC for Catchment Hydrology for the 2002-2003 summer vacation.

Third or fourth year students from a variety of disciplines are eligible to apply for the studentships which will provide experience in research projects at Griffith University, Monash University, The University of Melbourne, or CSIRO Land and Water, Canberra.

This year the CRC is also seeking students with high level numeracy, modelling and computer software skills to complement current research initiatives.

The Studentships provide $400 per week for 8-12 weeks during December to February, and are open to Australian or New Zealand citizens or Permanent Residents of Australia only.

For electronic application forms and further information: http://www.catchment.crc.org.au /studentships

For specific information on research fields, visit: http://www.catchment.crc.org.au

For further details: Virginia Verrelli, 03 9905 2704 (fax: 03 9905 5033, email: crcch@eng.monash.edu.au).

Applications (electronic only) close: Friday, 25 October 2002.

CRC PROFILE

Jianping Lin

(The University of Melbourne, School of Anthropology, Geography, and Environmental Studies)

All of my Degrees were concerned with water chemistry. My undergraduate study was in marine chemistry specialising in sea and estuarine waters. My Masters thesis examined the water of the Yarra river estuary in Melbourne. Finally, my PhD focused on water quality in Sugarloaf Reservoir and Melbourne tap water.

It is true that my life is also concerned with water. I grew up at Hangzhou in China where the Qiantang river flows past the edge of the city, and there is a large lake near the city centre. I spent three years in a beautiful Chinese coastal city, Qingdao, for my undergraduate study. After graduation I had several years in a research institute in another Chinese coastal city, Xiamen, where our office and apartment were only a few metres from the sea. Now I am working and living in Melbourne, an Australian coastal city. However, I cannot see the sea every day.

My specialist areas are environmental chemistry, water chemistry, analytical chemistry, and water and wastewater treatment. My research interests are focused on the improvement of water quality from the point of people's health and safety. At the moment my research is concerned with the deterioration of water quality affected by the water distribution system. This work is funded by the University of Melbourne Research and Innovation Office.

A paper "Study of corrosion material accumulated on the inner wall of steel water pipe" has been published in "Corrosion Science" (Vol.43(11), pp 2065-2081, 2001). Research is continuing into copper corrosion and trihalomethanes in the distribution system for drinking water. I have recently been awarded a German funded DAAD Short Research Visit, for a two-month cooperative research study on tap water quality affected by corrosion.

I have been involved with some water quality projects with the CRC for Catchment Hydrology. In particular looking at water quality in sand slugs as part of the Granite Creeks and Murrumbidgee projects (Projects 6.3 and 2.1). This research is in its early days.

Jianping Lin
Tel: (03) 8344 4428
Email: jianping@unimelb.edu.au

WHERE ARE THEY NOW?

Report by Scott Wilkinson

I'm a post doc at CSIRO Land and Water, Canberra. I have been told that Victorians don't travel well, and it has certainly taken a while to get used to "The National Capital." Being north of the Murray, our nightly TV news dispenses a weighty and unfamiliar dose of people running while holding the ball, and the barest snippets of AFL. Canberra's frosty mornings are less easily overcome than simply pressing a mute button. However, the blue sky days are a delightful recompense and Namadgi National Park is a mountain biking and bush walking joy.

At CSIRO Land and Water I'm based in the newly-formed Rivers and Estuaries group, with Ian Prosser. Our work centres on identifying patterns of sediment erosion, transport, deposition and export; that is, catchment scale sediment budgeting. For this task we are using the SedNet model developed here during the National Land and Water Resources Audit. SedNet can identify sources of sediment that affect in-stream habitat and also nutrients that affect water quality. The model is now in demand by regional catchment management agencies as a method for identifying "hotspots" in sediment supply and we are making refinements to the process representations in the model to refine it for this task.

I'm also coordinating a project funded by the National Rivers Consortium which is extending the spatial analysis methods developed with SedNet to other stream health issues. The aim is to develop techniques that help in prioritising where to implement a wide range of stream rehabilitation activities including riparian revegetation, grazing management, buffering of sediment runoff and improving ecological condition. We are tackling this by quantifying physical processes such as reinforcement of banks by vegetation and stream shading as well as assessing drivers of ecological function.

All this stuff has been a leap into a larger context than the process analysis my PhD involved. My thesis is currently being examined, and it addressed the question of what processes and channel conditions are required to create pool habitat? Pools are vital to stream habitat and ecological diversity and stream rehabilitation is often aimed at protecting existing pools or reinstating them where sedimentation or erosion has degraded them. Many of the pools in streams are associated with the pool-riffle sequence, so I focussed on the hydraulic processes and resulting sediment transport dynamics that develop and maintain alluvial pool-riffle sequence morphology. I used a combination of laboratory modelling and field measurement, and without boring you with details here, the findings identified several important processes in addition to the obvious scour around channel obstructions (LWD, bedrock outcrops etc). The results have implications for how environmental flows are released, and the design of stream rehabilitation works to enhance pool-forming processes.

I finished writing my thesis in June this year; the last four months of writing-up were part-time. To other postgrads, I can repeat the mantra you have no doubt heard about the benefits of finishing one thing before starting another. Anyway, it was bliss to regain weekends again.

I would like to take this opportunity to thank the CRC for facilitating such a stimulating PhD experience. In particular, my supervisors Bob Keller and Ian Rutherfurd, and all the CRC managers, researchers and students at Monash. Long live Wholefoods! My current work has many synergies with Program 6 of the CRC and so I may continue to be "associated" with the CRC for some time yet!

Scott Wilkinson
Tel: (02) 6246 5774
Email: scott.wilkinson@csiro.au

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SCHOLARSHIP FUNDING INCLUDES:
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The Centre's approach includes demonstration sites, and interaction with industry co-supervisors in postgraduate work. Multi-disciplinary collaboration is encouraged. Applications are invited from graduates with relevant qualifications including engineering, economics (including resource/socio-economics), environmental and earth sciences (including meteorology, geography and geomorphology), applied mathematics and computer sciences.

NOTE: Positions are only open to Australian or New Zealand citizens or Permanent Residents of Australia.

For electronic application forms and further information, contact Virginia Verrelli on crcch@eng.monash.edu.au (phone: 03 9905 2704; fax: 03 9905 5033) or visit www.catchment.crc.org.au

Applications (electronic only) close: Friday 25 October 2002.

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CENTRE OFFICE:
CRC for Catchment Hydrology
Department of Civil Engineering
PO Box 60 Monash University,
Vic 3800
Telephone: +61 3 9905 2704
Facsimile: +61 3 9905 5033

crcch@eng.monash.edu.au

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

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- Predicting catchment behaviour
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- Sustainable water allocation
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- Climate variability
- River restoration

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