NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 134 FEBRUARY 2005

A NOTE FROM THE DIRECTOR

Rodger Grayson

Inside...

COOPERATIVE RESEARCH CENTRE FOR
CATCHMENT HYDROLOGY

WELCOME TO 2005

Welcome to 2005 and the final five months of the CRC for Catchment Hydrology! The fabulous news of a successful eWater CRC bid arrived just before the Christmas break. This has brought into sharp focus the planning of our CRC's final phase of delivery. The "just one plan" approach that we have been following since our reviews last year means that the resources are in place for a very busy final few months.

By the time you read this, the first of our Catchment Modelling Toolkit training for 2005 will be complete, with workshops on several Toolkit products following the Hydrology and Water Resources Symposium in Canberra in late February. Our research teams also have a strong presence at this year's Symposium, which again will provide an excellent opportunity to talk with and learn from the broader water industry. March and April will focus on the final stages of software development and research activity, leaving May and June for completion of milestones and preparation for this year's Catchment Modelling School (CMS). The CMS will be held in both Sydney and Brisbane during July, with seven days of workshops in each city. June will include our final "annual workshop", which this year will include time for celebrating 13 years of our CRC.

The coming months will also see some major upgrades to our existing products. New versions of MUSIC, SCL, SedNet, Aquacycle and RAP are expected, along with public releases of our whole-of-catchment modelling system (E2), and an approach to the modelling of river salinity that will be applied across Victoria, New South Wales and Queensland. The release of E2 also provides the platform for the delivery of outcomes from several of our research projects that have been focusing on particular components of catchment systems, such as riparian zones and irrigation areas.

Following on from the end of 2004, we will be continuing a major communications push on the pros and cons of models, modelling and considerations in model choice. This is a particularly important activity in preparation for the eWater CRC, where many model-based products are proposed that will present considerable technical, scientific and philosophical challenges to the eWater research and development teams. So far we have published an introductory paper on model choice and one on water quality models, with more planned (available at www.toolkit.net.au/modelchoice). We will also be running a series of seminars over the coming months and details will be posted on the Toolkit and CRC websites, as well as in *Catchword*.

Of course the first half of 2005 will also be a critical time for the establishment of the eWater CRC, with legal and administrative arrangements having to be in place by 1 July 2005. While detailed project development will wait until later this year, administrative structures and some key positions will be finalised in the coming months. This will also be an important time for Parties and the broader NRM industry to think about how best to engage with eWater to maximise its benefit to the land and water management in Australia.

Well the next five months are shaping up to be a most exciting and fulfilling phase of our CRC. I am inspired by the enthusiasm and dedication of the research teams and look forward to completing our Mission - a Mission that was developed for our 1999 rebid and I believe has been central to us maintaining such a strong focus over the last six years.

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

Thanks to the fabulous support from our Parties, and the enthusiasm and dedication of research teams and support staff, I am confident that we will deliver this capability and in doing so, provide a solid basis for significant expansion in the eWater CRC.

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

Report by Geoff Podger and Alice Best

A new method for the estimation of the base flow recession constant

Introduction

Many of the rainfall runoff models commonly used to model runoff in catchments include a store that is used to model the base flow. This is the case for all of the models in the rainfall runoff library (RRL – see www.toolkit.net.au/rrl) with most containing one store, the Sacramento model containing two stores and the TANK model multiple stores. The stores are filled by infiltration from the surface by an infiltration function (Simhyd and AWBM) or from an upper store (Sacramento and Tank).

The models work by calculating the outflow from the store as a function of the head above the outlet multiplied by a constant. The constant is known as the base flow recession constant. As an example, assuming a head of 100 mm and recession constant of 0.1 day^{-1}, the outflow would be 100*0.1 or 10 mm/day. As the head decreases so does the amount of water leaving the store. In theory this will continue on forever but in practice will be limited by the precision of the computer model. In some models evaporation from the store or cease to flow limits may constrain the release of water.

These models are trying to represent physical processes that are occurring in catchments. The storage size represents the storage of water in the soil. It is a function of soil type (depth, porosity and permeability) and the topography of the catchment. Catchments with deep porous soils have large storage and catchments with very porous soils have large recession constants. In most catchments all of these parameters will vary considerably spatially and, in most cases, there is insufficient data to estimate them. The lumped rainfall runoff models represent an average of these physical parameters for the catchment.

When calibrating a rainfall runoff model, initial estimates for storage sizes are made based on an assessment of the soils in the catchment. The estimate of recession constants is usually made by looking at recessions of observed flows. When flow is plotted on a logarithmic scale, components of the recession appear as straight lines. The slope of these lines represents the recession constant. More often this is done by eye, which is very subjective, or the parameter is found by some optimised search.

Different modellers, search algorithms and objective functions will lead to different estimates of recession constants. This is due to the difficult nature in separating out the various components of recession. When rain falls on catchments, there are a number of different storages that fill and empty over time. The main components are surface runoff, interflow and base flow. Each has storage and an associated recession constant. Surface runoff occurs rapidly and has a large recession constant; interflow occurs quickly and has a moderate recession constant but smaller than surface runoff; and base flow has a much smaller recession constant. This varies considerably between catchments with some catchments having virtually no base flow and others having long periods of base flow.

A further complication is the spatial nature of catchments and the lumped model representation of distributed processes in catchments. Rainfall will not fall equally across the catchment and travel time from upper and lower parts of the catchments are different. At any point in the catchment, the soil moisture will be different and hence the amount of flow produced will be different. The lumped model aims to represent things on average, such as average travel time and soil moisture content and is aiming to get the flow reasonably close on average.

Existing methods for estimating base flow recession

There are numerous methods for estimating base flow recessions. Many methods rely upon plotting recessions on a logarithmic axis and using an averaging technique (Nathan and McMahon, 1990). Others use filtering methods to separate out the base flow component of flow (CRC for Catchment Hydrology, 1996) and then estimating the recession from the filtered base flows. One of the major problems with these techniques is making a distinction between the components of the recession; surface, inter and base flow. The distinction between interflow and base flow is very difficult to estimate. Quite often these methods will include components of interflow in the base flow. Consequently, base flow is typically over estimated.

Many of these methods also have difficulty in dealing with gaps in flow records and, in particular, gaps in recessions. Flow data with many random gaps can cause these methods to estimate an incorrect recession constant. They also have problems where small rainfall events interrupt steady recessions.

Getting the amount of base flow in models correct is extremely important where the models are used to model water quality. Typically the concentration of constituents for surface runoff and interflow is considerably different from base flow. This is evident when modelling salinity where base flow salinities are typically higher than surface salinities. Quite often models that have been calibrated for water quantity have to be recalibrated when water quality is modelled. The base flow component of these models often needs to be reduced. This was noted in some NSW rivers where a base flow filter was used to estimate base flow from the catchment. The salinity records for these streams showed two distinct regimes, one of rapidly varying salinities and one of constant salinities. The areas of constant salinities occurred during times of base flow. When compared to the filtered base flow it was noted that the filter consistently over-estimated base flow.

New method

As part of the work involved in developing the Forest Cover Flow Change (FCFC) tool (to be released on the Toolkit web site during March), an estimate of a base flow recession constant was required. A new method was developed to determine this constant to avoid having to rely on optimisers, determining this number, and getting it wrong.

The method works by identifying the three major components of a recession; surface flow, interflow and base flow (Figure 1.1). When plotted on a log axis there are six possibilities (Figure 1.2):

1. Surface flow only
2. Surface and Inter flow
3. Surface, inter and base flow
4. Interflow only
5. Inter and base flow
6. Base flow only

Recessions are classified into one of the six categories based on the slope of the recessions. Recessions that fall into categories without a base flow component are rejected (Categories 1, 2 and 4). The remaining recessions are then analysed by trying to fit lines of best fit to identify the base flow component.

The method works by:

1. Identifying every recession i.e. where the flow is continually decreasing. Note: gaps and small rises in the recession cause the start of a new recession.
2. Identifying and removing the surface flow component. This is identified where the slope of the recession on a logarithmic plot is greater 0.3. This is based on recommendations in Nathan and McMahon (1990).
3. After removing surface flow and provided there are more than two points remaining, a line of best fit is estimated for the log of flows. If the slope is less then 0.1 this is considered as base flow, if not it is flagged as interflow or combination of interflow and base flow.
4. If there are more than five points in the recession, the recession is assessed for components of interflow and base flow. This is done by progressively trialling two lines of best fit, starting with the top line in the top two points and bottom line in the remaining points and then moving down a point at a time until the bottom two points are reached. The combination of lines with the best combined r^2 is accepted as the best fit. If the slope of the lower line is less than 0.1 then this is considered as base flow.

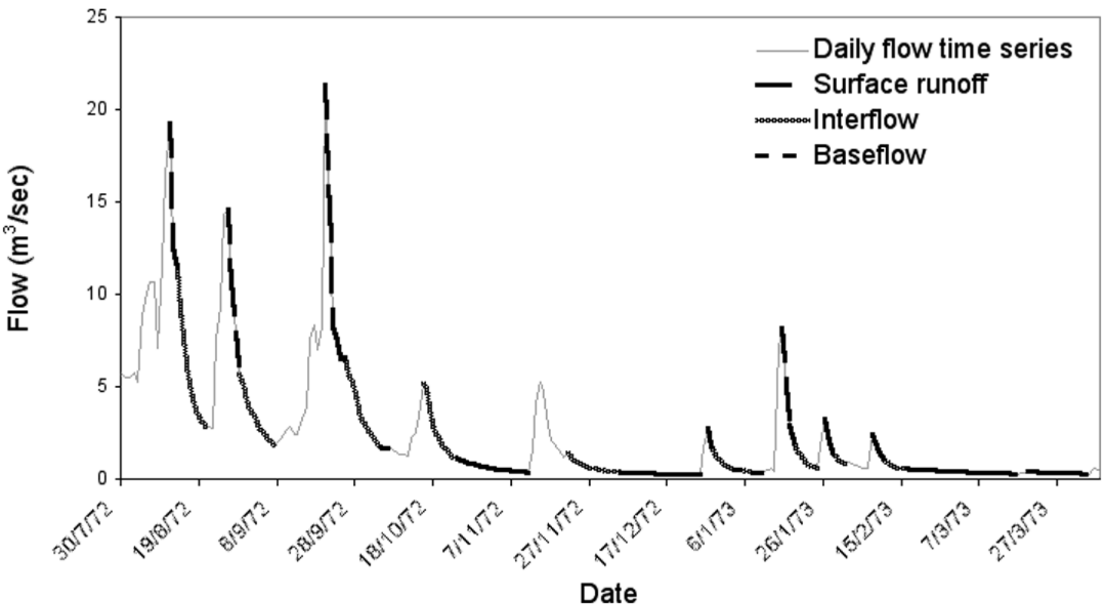

Figure 1.1: Examples of surface flow, interflow and base flow in hydrograph recessions

NEW TECHNICAL REPORT

Erosion in Forests: Proceedings of the Forest Erosion Workshop - March 2004

by

Jacky Croke
Ingrid Takken
Simon Mockler

Technical Report 04/10

The material in this report is the product of a three-day workshop on Erosion in Forests held in Canberra during March 2004, the third in a series of documented workshops over the last ten years.

The aim of this workshop was to draw together participants in forest research, management and environmental conservation to discuss scientific findings, implications and key issues for sustainable management. This was achieved through formal presentations, field-group discussions and experimental demonstrations.

The collection of papers in this volume represents a collection of research in the major areas of forest management and incorporates the diverse range of forest management themes including water quantity, quality, fire management and sustainability that are taking place in forest research presently.

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NEW TECHNICAL REPORT

Estimating Extractable Soil Moisture Content for Australian Soils

By

Tony Ladson
James Lander
Andrew Western
Rodger Grayson

Technical Report 04/3

This report uses an unconventional approach to estimating plant available water content for Australian soils. Instead of using laboratory measurements of soil properties, the authors have collected actual measurements of soil moisture from a wide range of field studies around Australia.

In total, extractable soil water capacity is presented for 180 locations that include the six States and two Territories. The report also compares estimates of extractable soil moisture from field measurements with those from the Atlas of Australian Soils.

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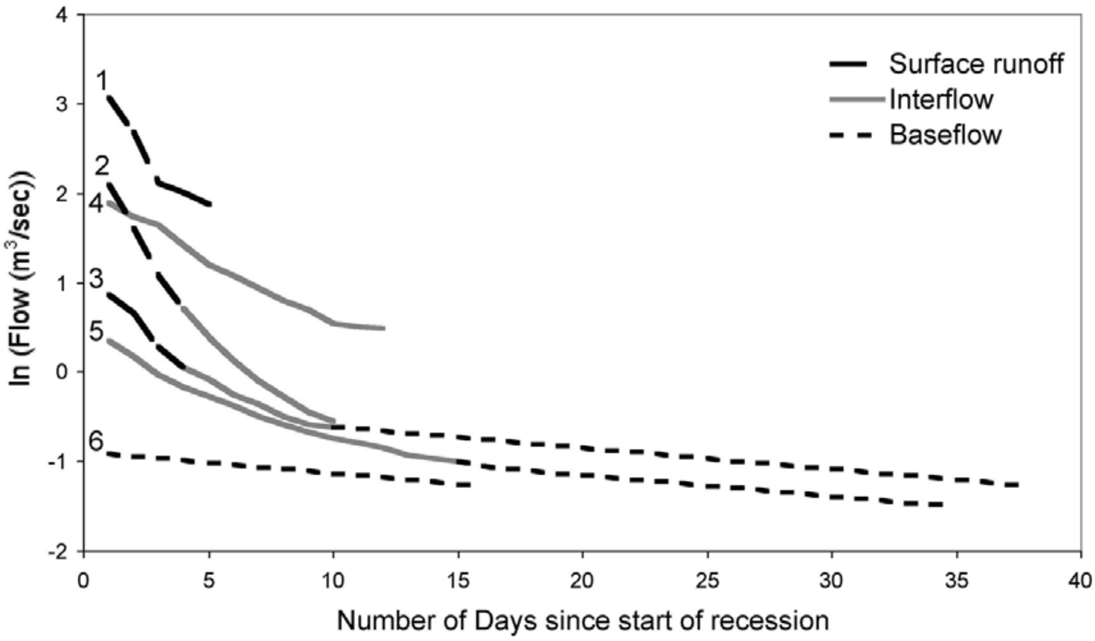

Figure 1.2: Examples of different flow components in recessions

5. After these steps the recessions are filtered down to a series of base flow recessions. Note that in this process some of the recessions will not be considered. The slopes of these recessions are then added together on a days weighted average - the recessions with the greatest number of days getting the greatest weighting.

6. The final result is a single number that represents the base flow recession constant.

Conclusion

This method was trialled on all of the catchments used for developing the FCFC tool (forest and cleared). It was also trialled on several of the catchments used in the RRL examples. These examples comprise a range of different sized catchments and different climatic conditions. Both ephemeral, with steep recessions, and perennial, with long recessions, were trialled. The results of this method were compared with manual and optimisation methods for deriving base flow recessions constants. This method obtained the same or, in our judgment, a more realistic estimate of the base flow recession constant. The method also performs well for gaps or small events breaking recessions.

Given the uncertainty in estimating recession constants with optimisers, particularly where there are multiple stores and multiple parameters to be solved, this method offers a more robust approach. Deriving the base flow recession constant by this method allows one of the parameters to be taken out of the optimisation. An experienced modeller could achieve similar results to this method by focusing on fitting components of recessions however this is subjective and difficult to reproduce. This method achieves a comparable result and is reproducible.

References

CRC for Catchment Hydrology. (1996) Hydrological Recipes. Estimation Techniques in Australian Hydrology. Section 6.2. pp 77-80.

Nathan, R.J. and McMahon, T. A. (1990). Evaluation of automated techniques for base flow and recession analysis. Water Resources Research, 26, 1465-1473

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER WALLBRINK

Report by John Hornbuckle and Evan Christen

Predicting Irrigation Return Flows

Introduction

Previously, the focus of the Land-use Impacts on Rivers Program of the CRC for Catchment Hydrology was limited to dryland areas. However, in the last twelve months a major effort has been undertaken by the 2A Project team to incorporate irrigation land-use modelling capability into the CRC for Catchment Hydrology Toolkit. The first release of this modelling capability will occur in E2 with an irrigation module that will give users the ability to model irrigation land-use impacts on river systems. In most catchments irrigation accounts for a significant proportion of water use (Figure 2.1), hence any whole-of-catchment modelling system needs to have an adequate representation of irrigation areas operating within the catchment, to be sensible.

The challenge for the 2A Project team has been to develop a conceptual understanding of the key drivers for water use and drainage return flows in irrigation areas and to incorporate this understanding into a basin or whole-of-catchment scale model such as E2. This is not trivial considering that in an average catchment 72% of the consumptive water-use is for irrigation and the model needs to be simple enough to integrate with the concepts and use requirements of E2 while still delivering adequate representation of the impacts on river systems associated with irrigation.

To gain an understanding of the complexity of the processes occurring within an irrigation area we only need to look at Figure 2.2. It can be seen that in just a small area (~4 km^2) a multitude of hydrological processes is occurring. Firstly we have multiple land-uses ranging from perennial horticultural crops like grapes and citrus to annual crops such as rice and pastures which have totally different water requirements and management regimes. This is combined with a mosaic of varying soil types for each of these crops (i.e. wheat grown on clay, wheat grown on loam and wheat grown on sand). Further, a mosaic of irrigation systems ranging from continuous water ponding for rice crops to subsurface drip irrigation for the higher value horticultural crops, and the presence of subsurface drainage systems to control water tables ensures the complexity of representing such a system hydrologically.

The approach undertaken within the irrigation module for E2 has been to use a lumped model to simplify this complexity to fit within the E2 framework and available data requirements while still providing an adequate representation of the hydrological processes occurring

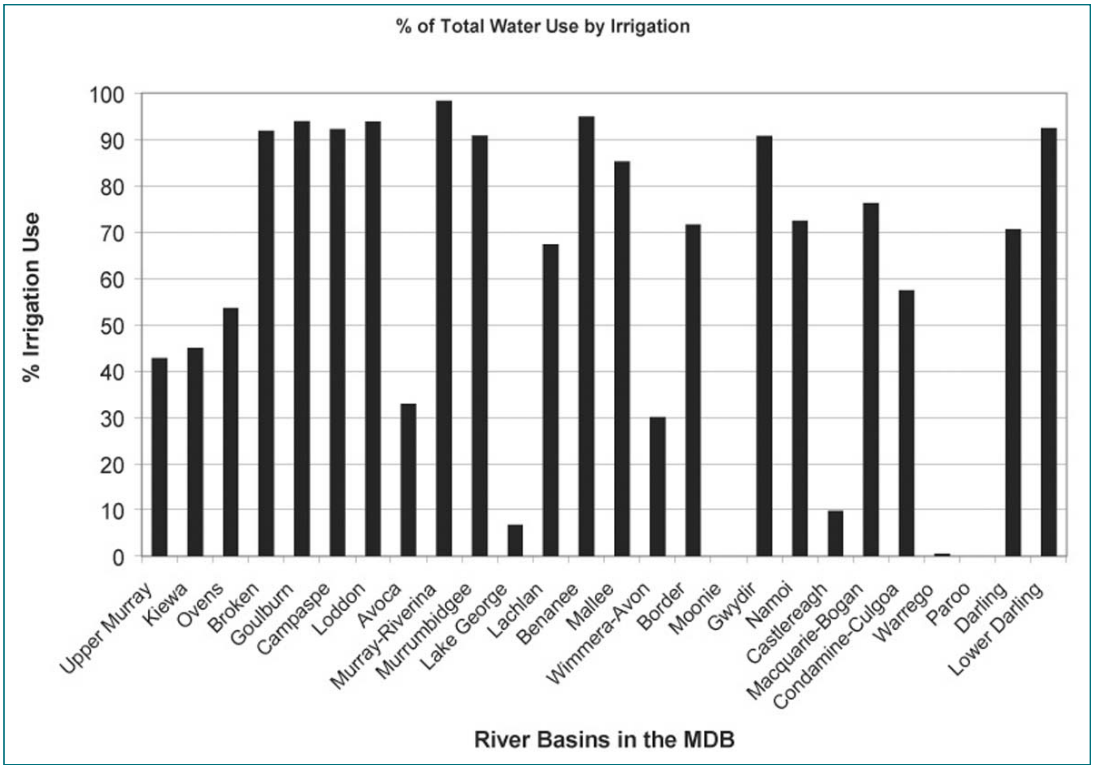

Figure 2.1. Irrigation water use as a percentage of total water use for river basins in the Murray Darling Basin system, (MDBC, 2004).

NEW TECHNICAL REPORT

CLASS – Catchment Scale Multiple Land-use Atmosphere Soil Water and Solute Transport Model

by

Narendra Kumar Tuteja
Jai Vaze
Brian Murphy
Geoffrey Beale

Technical Report 04/12

CLASS is a distributed, eco-hydrological modelling framework that deals with water and solute movement from hillslope to catchment scale. This report describes the modelling framework, CLASS, which is at the more complex end of the modelling spectrum, but where there has been a major effort made to exploit the ever-increasing range of available data for setting up and running the model.

Ultimately, CLASS will be incorporated into the Catchment Modelling Toolkit (www.toolkit.net.au/class) and will be one of a number of models of different complexity that represent water and solute movement.

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SERIES ON MODEL CHOICE

The Model Choice series is designed to assist you to better understand catchment modelling and model selection. The first publication entitled 'General approaches to modelling and practical issues of model choice' is enclosed with this month's edition of *Catchword*

The second in the series entitled 'Water quality models – sediment and nutrients", is now available for downloading from the Catchment Modelling Toolkit web site at http://www.toolkit.net.au/modelchoice

A printed copy of the second in the Model Choice series will be included in next month's *Catchword*.

Additional printed copies can be obtained by contacting Virginia Verrelli at the Centre Office.

Figure 2.2. Aerial photograph of irrigation area showing complexity of multiple land-uses.

in an irrigation area and the associated impacts. Figure 2.3 presents conceptually the major drivers and management levers which dictate the quantity and quality of irrigation return flows. The irrigation module being developed for E2 will begin to capture this understanding and provide a tool that allows the investigation of alternative management scenarios and impacts of irrigation return flows to river systems.

Overview of irrigation module in E2

The core building blocks or components of the irrigation module developed for E2 consist of:

1. An evapotranspiration component based on FAO 56 methodology (Allen *et al.* 1998) for determination of crop evapotranspiration
2. A soil water balance model based on the CERES-Maize model (Jones and Kiniry, 1996)
3. An upflux component described by Wu, Christen and Enever (1999) to account for evapotranspiration from a shallow watertable that incorporates a root depth development model (Borg and Grimes, 1986)

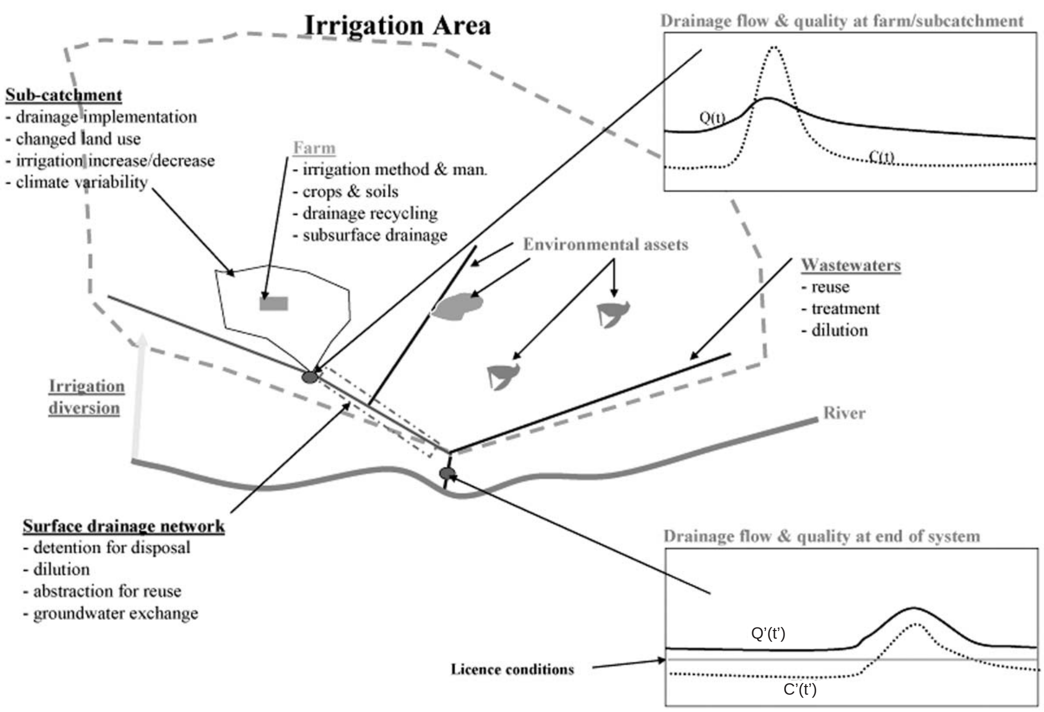


Figure 2.3. Conceptual model of drivers and management levers dictating quality and quantity of irrigation return flows

4. A watertable and subsurface drainage component that accounts for artificial subsurface drainage systems such as tile drainage (Smedema and Rycroft, 1983)

5. An irrigation system component used to simulate the various irrigation system types (drip, sprinkler and flood) and the irrigation management regime

6. An on-farm storage/recycling system component based on BASINMAN (Wu, Christen and Enever, 1999) used to simulate storage and recycling systems

These building blocks or components are used to construct what is known as a Cropping Unit (CU) in the irrigation module. The CU can be thought of as representing a discrete land-use within the irrigation area which has the potential to generate return flows from the irrigation area.

The heart of the irrigation module consists of a series of CUs. These dictate the make-up of various components of crop, soil and irrigation system parameters that form a water balance. Each CU has a unique combination of crop type, soil type and irrigation/subsurface drainage system. This determines the behaviour of the water balance of the CU and ultimately the generation of drainage return flows from the irrigation area, either through surface runoff or subsurface drainage. The module accepts an infinite number of CUs which are used to represent the various cropping systems used in the irrigation area.

In constructing a model of an irrigation area using the module, the first process involves developing a set of cropping units which adequately represent the cropping systems which are present in the irrigation area. In practice this would most likely be accomplished with 10-20 CUs (See Figure 2.4).

Although each CU represents a major land-use inside the irrigation area, it does not take into account the various individual land-use units (i.e. individual paddocks) which make up the cropping unit. For example there could be 50 paddocks within an irrigation area that all have rice grown on clay soil using ponded water. On each of these 50 paddocks the water balance is unlikely to be the same due to a range of factors, particularly different crop planting dates. In order to capture this complexity within the irrigation module, the user has the ability to define the number of paddocks which form a subset of the CU and a planting duration over which paddocks have been sown. The model then constructs a series of water balances for each of these paddocks and assigns a random planting date to each of the water balances to take into account the fact that multiple paddocks are being represented by the CU. So while we may only have ten CUs representing an irrigation area, each cropping unit may consist of 50 similar paddocks so the irrigation module actually runs 500 individual water balances to simulate the individual paddocks which make up the CU. Figure 2.5 shows an example where for three cropping units a

TOOLKIT DATA PRODUCT

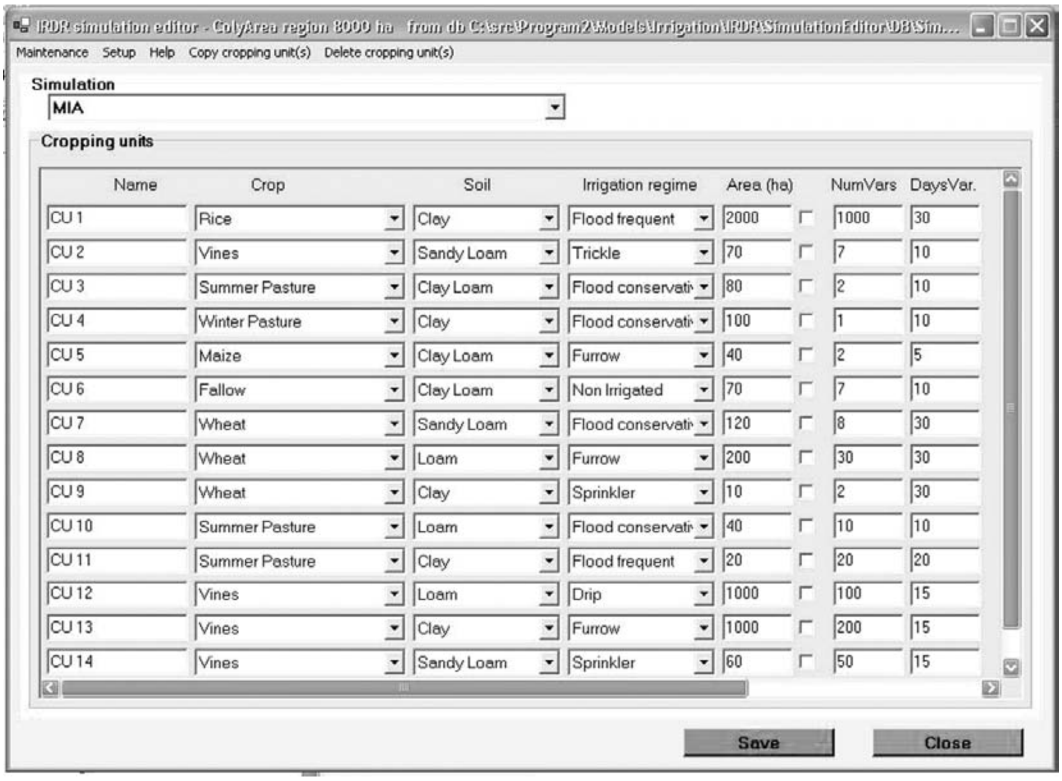
Soil Hydrological Properties for Australia

The first Catchment Modelling Toolkit data set has been released on the Catchment Modelling Toolkit website.

Soil Hydrological Properties for Australia (SHPA) provides continental coverage of soil properties relevant to catchment Modelling. This data set can be downloaded from www.toolkit.net.au/shpa

The data set provides estimates of twelve properties in total along with information on the uncertainty of the property estimates.

Further details of the data set development and its limitations are available in the data set documentation at www.toolkit.net.au/shpa



Name	Crop	Soil	Irrigation regime	Area (ha)		NumVars	DaysVar.
CU 1	Rice	Clay	Flood frequent	2000		1000	30
CU 2	Vines	Sandy Loam	Trickle	70		7	10
CU 3	Summer Pasture	Clay Loam	Flood conservati	80		2	10
CU 4	Winter Pasture	Clay	Flood conservati	100		1	10
CU 5	Maize	Clay Loam	Furrow	40		2	5
CU 6	Fallow	Clay Loam	Non Irrigated	70		7	10
CU 7	Wheat	Sandy Loam	Flood conservati	120		8	30
CU 8	Wheat	Loam	Furrow	200		30	30
CU 9	Wheat	Clay	Sprinkler	10		2	30
CU 10	Summer Pasture	Loam	Flood conservati	40		10	10
CU 11	Summer Pasture	Clay	Flood frequent	20		20	20
CU 12	Vines	Loam	Drip	1000		100	15
CU 13	Vines	Clay	Furrow	1000		200	15
CU 14	Vines	Sandy Loam	Sprinkler	60		50	15

Figure 2.4. Graphical User Interface (GUI) of the irrigation module showing Cropping Units (CUs) representing an irrigation area

total of 14 individual water balances are being modelled.

This approach allows the user to capture the complexity associated with an irrigation area, without having to model each paddock individually.

The scale of the irrigation area represented by the irrigation module is largely up to the end-user. The module can be used to model a single isolated river pumper or can be used to model an extensive multi-user irrigation area.

Conclusions

The irrigation module provides a solid foundation for incorporating irrigation land-use impacts into a whole of catchment modelling system such as E2. However, there are some limitations. The use of a lumped model does have drawbacks and the end-user will need to be aware of the assumptions behind the model. However, as a starting point it will capture the impacts that irrigation systems have on river systems in whole-of-catchment modelling environments such as E2.

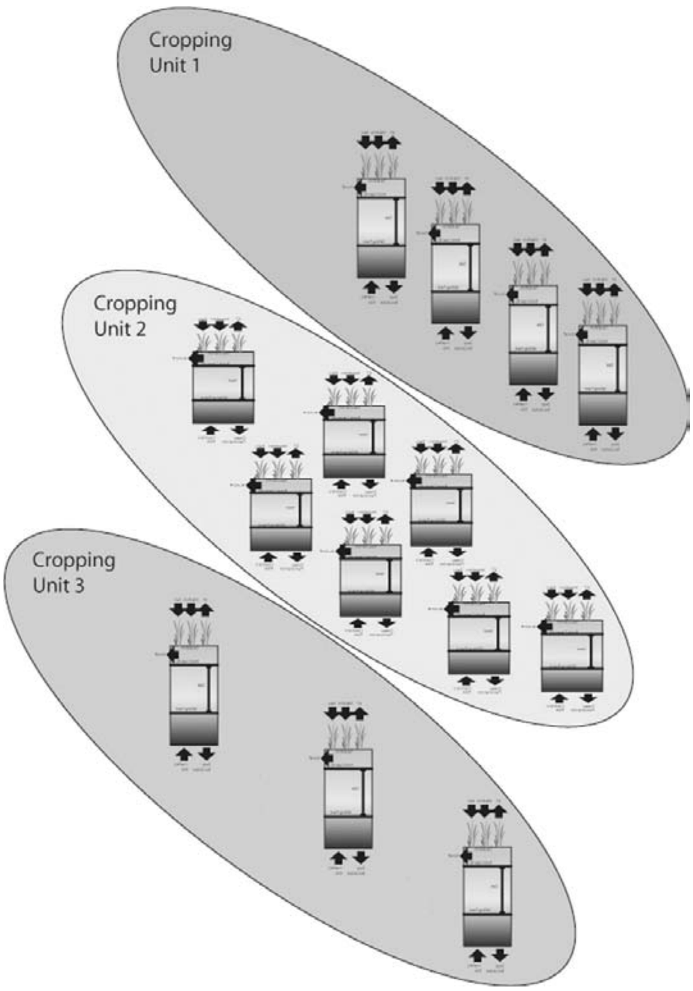


Figure 2.5. Representation of Cropping Units and multiple water balances occurring within each Cropping Unit

Future work developing a stand-alone application that includes a node-link network model inside the irrigation area (i.e. removing the lumping) is being undertaken and will overcome many of the limitations of the lumped model described above, however this will be at the cost of a more data intensive requirement.

References

Allen, R.G., Pereira, L.S., Raes, D. and Smith, M. (1998), Crop evapotranspiration – Guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper 56, FAO, Rome

Borg, H. and Grimes, D.W. (1986), Depth Development of Roots with Time: An Empirical Description, Trans. ASAE, 29(1), 194-197

Jones, C.A. and Kiniry, J.R. (1996), CERES-Maize s simulation model of maize growth and development, Texas Agricultural and Mechanical Press, Texas, USA

MDBC, 2004 Water Use, Retrieved 7 Feb. 2005

http://www.mdbc.gov.au/education/encyclopedia/water_use/water_use.htm

Smedema, L.K. and Rycroft, D.W. (1983). Land Drainage: Planning and Design of Agricultural Drainage Systems, Cornell University Press, Ithaca, New York

Wu, Q., Christen, E.W., and Enever, D. (1999). Basinman - A water balance model for farms with subsurface pipe drainage and on-farm evaporation basin. CSIRO Land and Water, Griffith, NSW, Australia. Technical Report 1/99

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NEW TECHNICAL REPORT

Water Farms: A Review of the Physical Aspects of Water Harvesting and Runoff Enhancement in Rural Landscapes

By
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Peter Hairsine
Timothy Ellis

Technical Report 04/6

Water farming is an approach to the problem of managing the quantity of water input to our streams, and is an idea that has been around for thousands of years. In this concept, land managers are able to generate more runoff for a given amount of rain than would happen in normal circumstances. Historically, most examples focused on providing extra water from a farm for use on the same farm. However, there are considerable prospects for 'water farms' enterprises that use water harvesting techniques to provide additional water into the river system and new water markets. It is these prospects that have prompted this review.

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PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by John Tisdell

The structure of water markets

Introduction

When most people think of a market their mind turns to situations where sellers publicly advertise their goods, as in the case of the housing or car markets, or where buyers and sellers actively interact, such as at a stock exchange.

The environment in which buyers and sellers in a market interact is known as the market's structure. There are a number of different market structures. The most commonly known is the double market structure where traders actively interact. The best example of this is a stock exchange where buyers and sellers display offers to buy or sell. Another is bilateral trade in which individuals simply seek out someone else to trade with. I want to sell my car and, yes, Fred next door was looking for a car. There are also tender type structures such as English, Dutch and 'call' where central agencies coordinate trade.

So what types of water markets exist in Australia? Well, there are many depending in a large part on how the states reacted to the water reform process. In essence, while national water markets are developing, the political and institutional structure of water management in Australia dictated the development of water markets on a regional basis. Some state agencies have taken a minimalist role in developing water markets. Legislation was modified to break the nexus between land and water entitlements in order to allow trade, but have not been engaged in developing any market structures. In these situations bilateral markets have tended to develop in which farmers have to seek out others wishing to trade. Market information is very poor and the market is extremely inefficient in reallocating available water.

Other State Governments and regional water authorities, such as Goulburn-Murray Water, have taken an active role in establishing formal water market structures. These more formalised markets use call and double market structures.

Call market structures

Call water markets in Australia involve a governing agency calling for offers to buy or sell water for a given duration, after which the agency determines the maximum number of transactions possible and clears them a single price. A common question asked at field demonstrations is "Well, how is the market price determined?" This is often followed by "Why was my offer unsuccessful?"

In a call market the sell bids are ordered from the lowest to highest price and the buy bids are ordered from the highest to lowest price as shown in Table 3.1 below. Buy bids are filled, highest bid price downwards from the lowest sell bid price upwards until the market clears.

In the Table 3.1 example, Farm E lodged the highest buy bid price of $10 per unit. The 27 units demanded is filled from the sell bids of Farm A (10 units), Farm D (15 units) and Farm F (2 units). The next highest buy bid (Farm B with three $5 units) is filled from the sell bid of Farm F. The next highest buy bid of $2 is lower than the current sell bid $5 so the market clears. The market clears at $5 and 30 units are traded. Everyone who offered to sell at a price equal to or lower than $5 sold at $5 and everyone who asked to buy water at or above $5 bought water at $5, irrespective of their offer price. Farm A sold 10 units at $5; Farm D sells 15 units at $5; Farm F sells 5 units at $5; and Farm G's bid to sell was unsuccessful. Farm E bought 27 units at $5; B bought 3 units at $5, and Farm C was unsuccessful. Often after each call this information, excluding individual identities, is made publicly available. When this occurs it is known as an open call market. When only the clearing price (and quantity in some situations) is released it is known as a closed call market.

The CRC for Catchment Hydrology has now for many years conducted field demonstrations of water markets in action. At these demonstrations farmers are given

Table 3.1. Ordered offers in a Call Market

Sell Offers			**Buy Offers**		
Farm	Price per unit	Qty	Farm	Price per unit	Qty
A	1	10	E	10	27
D	3	15	B	5	3
F	5	8	C	2	10
G	6	10			

NEW TOOLKIT SOFTWARE

CatchmentSIM

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

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

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

TOOLKIT SOFTWARE

WRAM

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

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

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

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

model farms and gain hands-on understanding how the price is determined and what strategies need to be adopted to be a successful trader.

Double auction market structures

The double auction market structure is the most commonly known market structure. In these markets buyers and sellers actively post and accept offers in a public domain, such as a trading floor. During the period of a market many offers are posted and traded at the prices asked or offered, such as would occur in a stock exchange. Double auction water markets exist in the United States and are beginning to appear in Australia. In many double auction water markets bid reduction rules are applied. The rules require offers to improve on those available (standing).

In cases where the bid reduction rule is applied, the first ask to sell and bid to buy which are made stand until better offers are made. An ask with a lower price will replace the standing ask regardless of quantity. Similarly, a bid with a higher price will replace the standing bid regardless of quantity. Offers which do not improve on the standing offer price are rejected. The notion behind this is that it forces the prices to converge to competitive market prices. Where the goods are divisible, such as water entitlements, traders can accept all or part of the quantity offered. This leads to what is known as full and part trades. When the full quantity of an offer is accepted, all offers are cleared and the market is open to new asks and bids. When only part of an offer quantity is traded the remainder of the offer stands and the opposing offers are cleared. For example, if a player buys 5 ML of water of a 10 ML offer to sell, 5 ML will be traded and the 5 ML of the original ask will stand and trade will commence from the beginning with the new quantity.

Market structures for Australian water markets

The choice of a call or double auction structure needs to take account of a significant amount of literature on the relative merits of call and double auction markets, experimental findings in focus catchments, as well as more pragmatic logical issues.

The literature on the relative merits of call and double auction structures is divided. While some preliminary experimental evidence suggests that double water market structures may be superior to call water market structures, there are logical problems associated with conducting real time water markets in Australia at present. To trader in a call market one can lodge an offer over the internet, by phone or by mail. Given the isolation of many farms, trading in real time is difficult. In time I expect there will be an opportunity to interact over the internet in real time trading, but at present this is not an option for many in rural Australia.

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PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

Report by David McCarthy

Exploring the influence of seasonality of inflow and demand on stormwater utilisation

In recent years, pressure on water resources in Australia have become apparent. As a result, there has been an increasing interest in the use of water resources generated within the urban boundary (greywater, stormwater, wastewater, etc) for potable supply substitution. Stormwater reuse has great potential as it reduces detrimental stormwater impacts (Walsh *et al.*, in press) whilst also providing alternative water supplies. More importantly, stormwater is an abundant and easily available resource in most major cities.

This article reports on work being undertaken within the 'Development of Innovative Integrated Stormwater Treatment and Reuse Systems' research project. This project is a CRC Associate Project, led and funded by the Institute for Sustainable Water Resources (ISWR) at Monash University, with funding support from Melbourne Water, Brisbane City Council, Queensland EPA, New South Wales EPA and the Victorian EPA. It aims to determine the level of stormwater supply reliability that can be achieved within the constraints that urban development places on storage capacity. The following provides a brief outline of the work I have been involved in while being an ISWR/CRC summer student and mainly discusses one key finding – that seasonality of inflow and demand noticeably influences stormwater utilisation.

Analysis Method

To understand how catchment characteristics and water end use type impacts storage size requirements, a number of scenarios were analysed with variations in the following parameters:

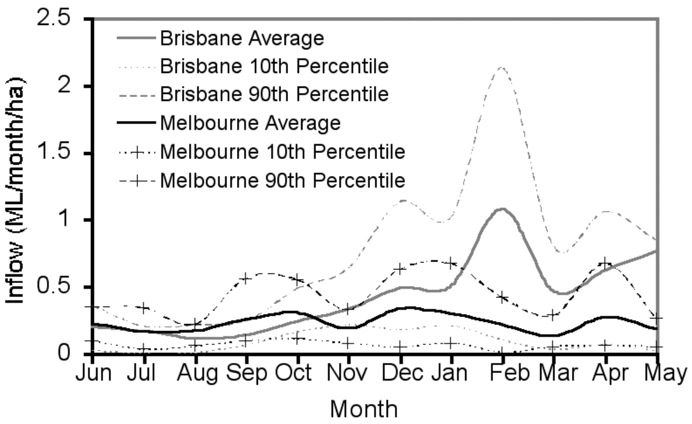
- Three different catchment imperviousness levels: 14%, 42% and 70%, representative of the range of urban development types;
- End use demand: constant daily demand (representing toilet flushing), seasonally varying demand (representing garden irrigation) and a combination of the two;
- Two storage types: covered (e.g. underground storages without evaporation) and uncovered (e.g. surface storages with evaporation); and,
- Climate variations: represented by Melbourne and Brisbane climates.

For each of the 36 scenarios derived, long-term (11 year) continuous simulation at a 12 minute time step for a range of storage sizes was conducted using the MUSIC model (CRC for Catchment Hydrology, 2003).

Results

As may be expected, it was found that for a given supply reliability and annual demand volume, an end use with a constant demand pattern requires a lower storage size than an end use that has a seasonal demand pattern (see Figure 4.1).

In the case of a constant demand, the relatively constant Melbourne inflow pattern resulted in a lower storage requirement in comparison to sub-tropical Brisbane despite the Melbourne inflow volumes being in



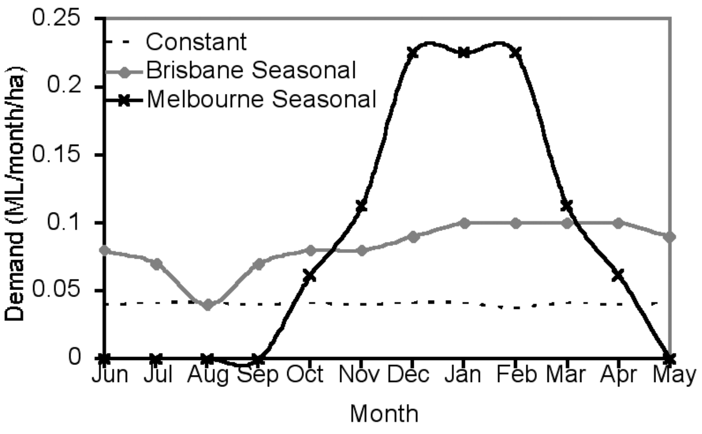


Figure 4.1: Inflow (top), constant demand and seasonal demand (bottom) for Melbourne and Brisbane for the 42% impervious catchment.

NEW MUSIC SOFTWARE - VERSION 2.1

MUSIC Version 2.1 is now available for downloading from the Catchment Modelling Toolkit website at http://www.toolkit.net.au/music

We recommend all registered MUSIC users log in as a Toolkit member, download the Version 2.1 MUSIC software installer and release notes, run the installer file and enter their user registration code to access the Version 2.1 software.

MUSIC Version 2.1 corrects an error in the algorithms that predicted Total Phosphorus (TP) and Total Nitrogen (TN) removal through the filter medium of a bioretention system. It also corrects an occasional error with flow mass-balance calculations in treatment systems, which occurred under unusual circumstances (usually when outlet sizes were very small).

Further details about the impact of this error are available in the release notes on the download page.

Visit www.toolkit.net.au/music

FRESHWATER ECOLOGY REPORT

Urban Stormwater and the Ecology of Streams

By

Chris Walsh
Alex Leonard
Tony Ladson
Tim Fletcher

Technical Report 05/4

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

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

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

the order of half of those occurring in Brisbane). This is due to Melbourne's relatively uniform inflow pattern providing a more constant inflow into the stormwater store, ensuring the supply is more reliable throughout the year. In comparison, Brisbane has a far more seasonal inflow pattern, stressing the store more during the dryer months (August to October).

On the other hand, Brisbane required smaller stores to supply seasonal irrigation demands than was needed in Melbourne. This is caused by the irrigation demand pattern for Brisbane being only moderately variable and loosely matching the regions inflow pattern (Figure 4.1). Melbourne's irrigation demand is significantly more seasonal, with around 85% of the irrigation demand occurring during the warmer five months.

Figure 4.2 provides another illustration of the influence of seasonality in inflow and demand on volumetric reliability. The storage-size-to-volumetric-reliability relationships for a constant reuse demand and a seasonal reuse demand in a 70% impervious catchment fall on top of one another, despite the constant demand being three times larger in volume than the seasonal demand. In the Melbourne setting, the provision of storage for a small constant demand is least onerous (14% constant in Figure 4.2) and for a large highly seasonal demand (i.e. where garden or open space is large, and thus impervious area is small) is most onerous (14% seasonal demand in Figure 4.2) with a store that occupies 1% of the catchment supplying approximately 30% of the demand over the eleven years of simulation.

Conclusions

It is recommended that in locations with constant rainfall/runoff patterns such as Melbourne, end uses that have predominantly constant demand patterns are selected in preference to the strongly seasonally varying end uses such as garden and open space irrigation. However, in locations which have more seasonal rainfall/runoff patterns and less seasonal irrigation demands, there is less need for a preference between indoor demands such as toilet flushing and outdoor demands such as irrigation.

For more information on this project, including other key findings, refer to 'Optimising storage capacity for stormwater utilisation' (Mitchell *et al.*, submitted).

References

Mitchell, V.G., McCarthy, D.T., Fletcher, T.D. and Deletic, A. (submitted). Optimising storage capacity for stormwater utilisation. Paper submitted for the International Conference on Urban Drainage, Copenhagen, Denmark.

Walsh, C. J., Fletcher, T. D., and Ladson, A. R. (in press). Restoration of streams in urban watersheds through re-designing stormwater systems: a hypothetical framework for an experimental watershed manipulation. Journal of the North American Benthological Society.

CRC for Catchment Hydrology (2003) MUSIC – Model for Urban Stormwater Improvement Conceptualisation – User Manual (v2).

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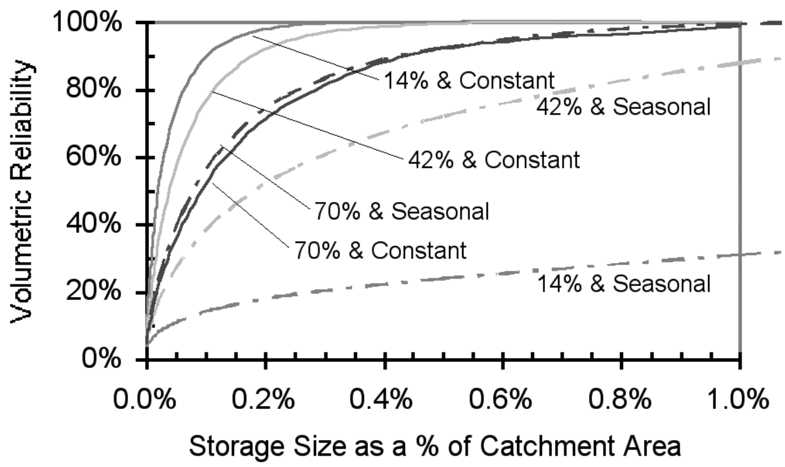

Figure 4.2: Relationship between volumetric reliability and storage size as a percentage of catchment area in Melbourne for differing urban development levels (14%, 42% and 70% impervious) and differing water demand patterns (constant and seasonal).

PROGRAM 5
CLIMATE VARIABILITY

Program Leader
FRANCIS CHIEW

Report by Sri Srikanthan

Stochastic generation of spatial daily rainfall

Rainfall data at a number of sites over large regions are required as inputs into water system models, like IQQM and REALM, to simulate present conditions as well as changes in system behaviour as a result of changes in climate and catchment characteristics and management practices. Climate can vary considerably from year to year, and stochastic data provides a means for quantifying the uncertainty in the hydrological system as a result of climate variability. To model a large region realistically, stochastic rainfall models must take into account the spatial dependence between rainfalls across the region.

The results from the application of the extended two-part model to generate the occurrence of daily rainfall were presented in an earlier issue of *Catchword* (May 2004). The rainfall depth on rain days were generated by using a two parameter Gamma distribution and spatially correlated random numbers. As in the case of a single site two-part model, the variability at the annual and monthly time scales was not preserved. To preserve the monthly and annual parameters, the daily rainfall generation model was nested in a monthly rainfall model and the monthly rainfall model in turn was nested in an annual rainfall model. The nesting of the models resulted in preserving the monthly and annual characteristics.

The developed model was applied to generate daily rainfall for five catchments/regions. They are Upper Woady Yaloak, Yarra, Murrumbidgee and Goulburn-Broken catchments and the Sydney region. The generated rainfall data were evaluated at daily, monthly and annual time scales. The results for the Murrumbidgee catchment are presented in this report. Thirty rainfall stations were used in the Murrumbidgee catchments, which are the same data set used by the CSIRO Land and Water in their study (obtained from CSIRO Land and Water). The locations of the rainfall stations are shown in Figure 5.1.

A comparison of historical and generated mean and standard deviation of daily rainfall for Murrumbidgee catchment is shown in Figure 5.2. Figure 5.3 shows the comparison of mean number of wet days and maximum daily rainfall for historical and generated. The mean and standard deviation of dry and wet spell lengths are presented in Figures 5.4 and 5.5 respectively. Figure 5.6 shows the comparison of cross correlation for rainfall occurrence and rainfall depths.

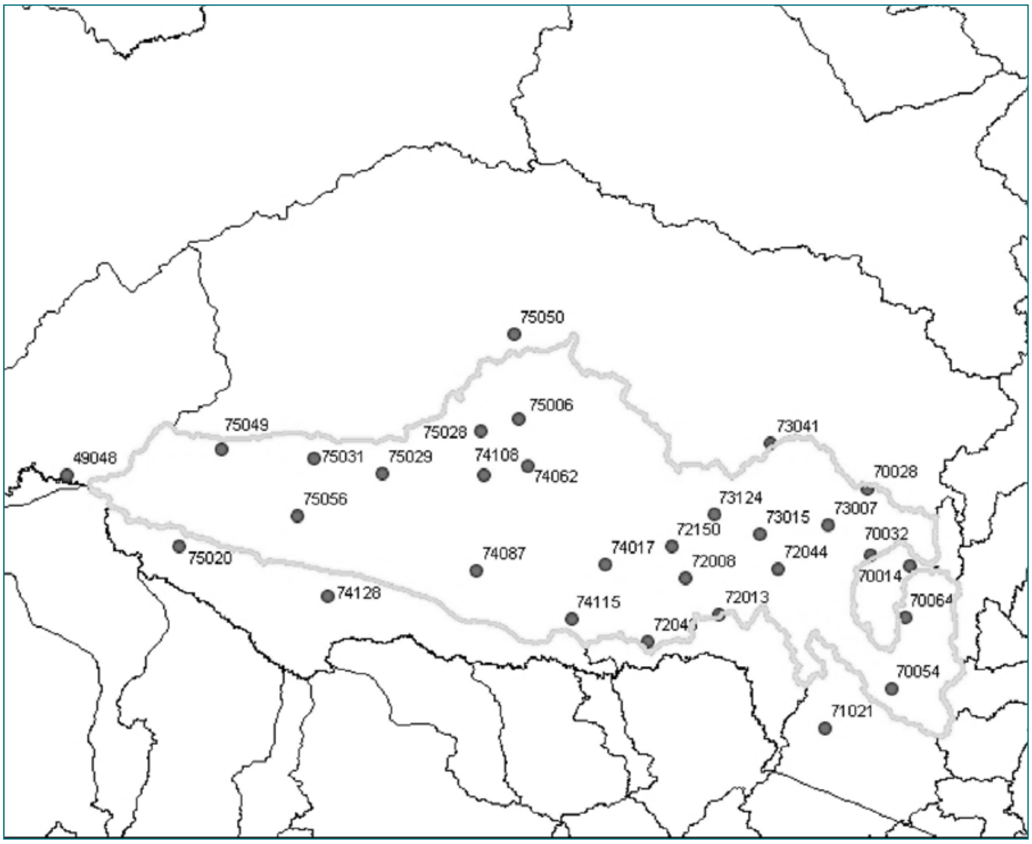

Figure 5.1 Location of rainfall stations in the Murrumbidgee catchment

CATCHMENT MODELLING SCHOOL 2005

Dates for the Catchment Modelling School are now finalised.

BRISBANE:
30 June – 8 July 2005
at Griffith University

SYDNEY:
14 July – 22 July 2005
at the University of Sydney

The two Schools represent the climax of our research and product development over recent years.

Further information and details will be circulated through *Catchword* and the Catchment Modelling Toolkit website at www.toolkit.net.au/school

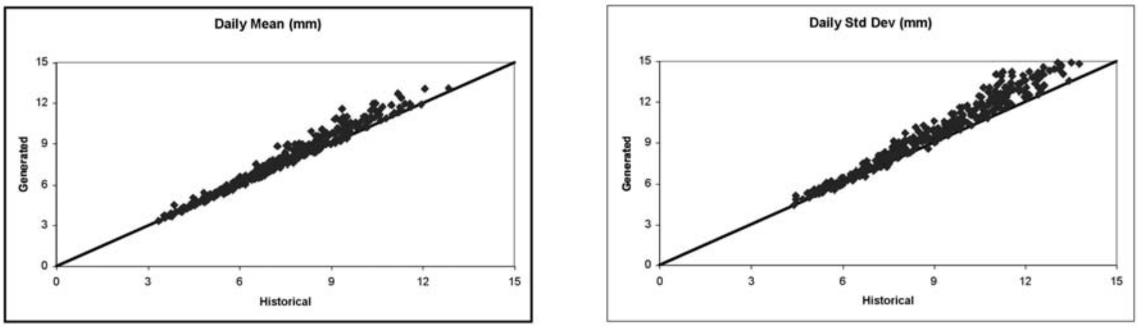

Figure 5.2. Comparison of historical and generated mean and standard deviation of daily rainfall.

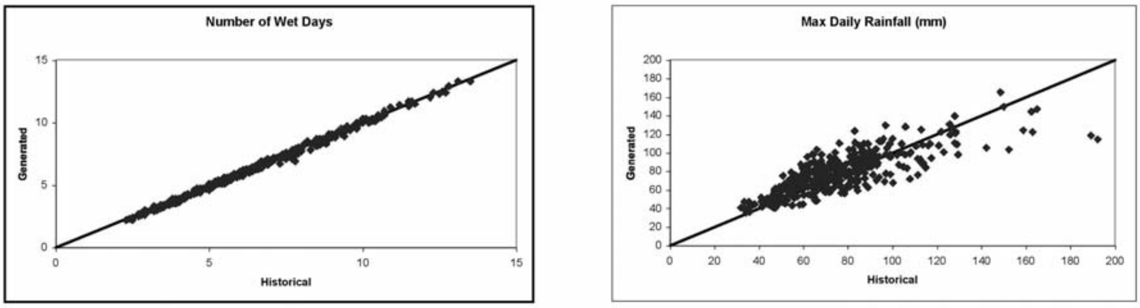

Figure 5.3. Comparison of historical and generated mean number of wet days and maximum daily rainfall.

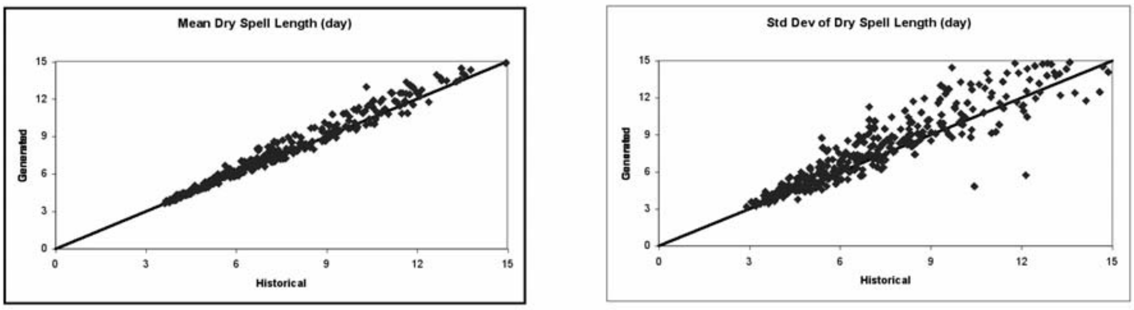

Figure 5.4. Comparison of historical and generated mean and standard deviation of dry spell length.

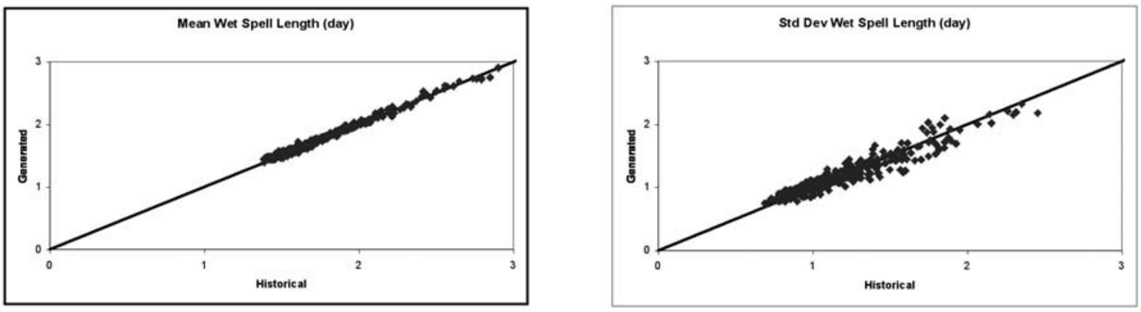

Figure 5.5. Comparison of historical and generated mean and standard deviation of wet spell length.

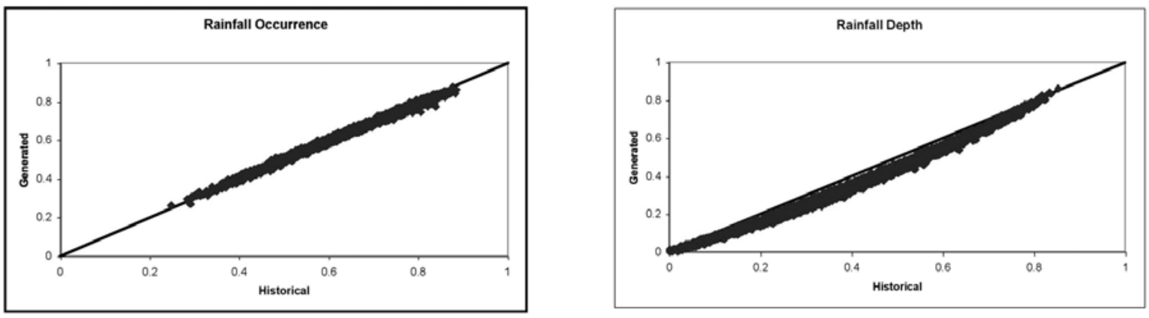

Figure 5.6. Comparison of historical and generated cross correlation for rainfall occurrence and depths.

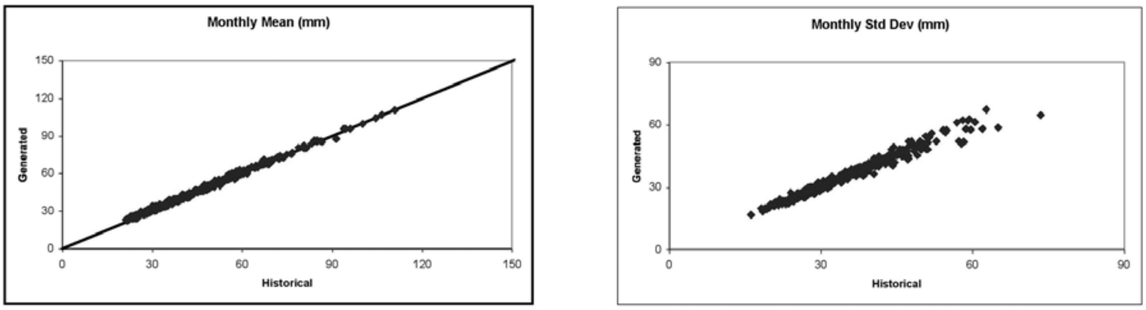

Figure 5.7.Comparison of historical and generated mean and standard deviation of monthly rainfall.

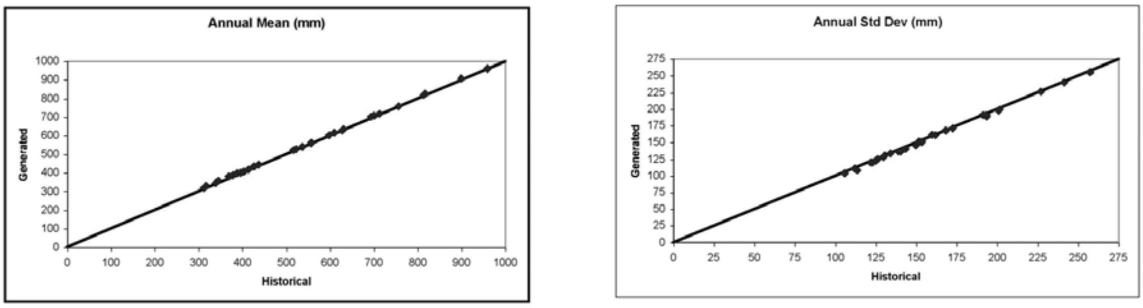

Figure 5.8. Comparison of historical and generated mean and standard deviation of annual rainfall.

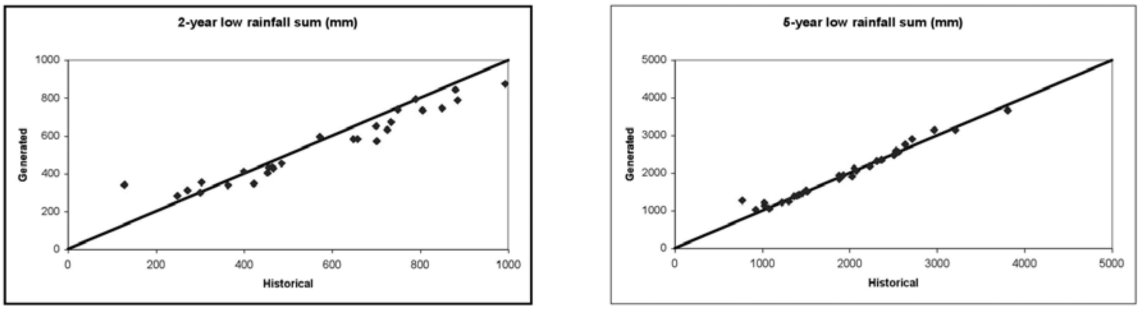

Figure 5.9.Comparison of historical and generated 2- and 5-year low rainfall sums.

The above figures show that the model satisfactorily reproduces the daily rainfall characteristics. The comparisons of mean and standard deviation of monthly and annual rainfall are shown in Figures 5.7 and 5.8 respectively. Figure 5.9 shows the comparison of 2- and 5- year low rainfall sums. Here also the monthly and annual characteristics are satisfactorily reproduced.

A CRC for Catchment Hydrology Technical Report is being produced to describe the model in detail and to present the results for the five locations. Once this is completed, the model will be incorporated into the Catchment Modelling Toolkit.

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NEW TECHNICAL REPORT

Stochastic Generation of Point Rainfall Data at Subdaily Timescales: A Comparison of DRIP and NSRP

By

Andrew Frost
Ratnasingham Srikanthan
Paul Cowpertwait

Technical Report 04/9

One of the goals of the Climate Variability Program in the Cooperative Research Centre (CRC) for Catchment Hydrology is to develop and test computer programs for generating stochastic climate data at timescales from less than one hour to one year and for point sites to large catchments. The appropriate models will be part of SCL (Stochastic Climate Library - a suite of stochastic climate data generation models), a product in the CRC's Modelling Toolkit (see www.toolkit.net.au/scl).

This report describes the evaluation of two point subdaily stochastic rainfall models - the Newman-Scott Rectangular Pulse (NSRP) and the Disaggregated Rectangular Intensity Pulse (DRIP). The models are evaluated using relatively long pluviograph data from ten major Australian cities and regional centres.

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

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

8TH INTERNATIONAL RIVER SYMPOSIUM 2005

Water and Food Security – Rivers in a Global Context
6-9 September 2005, Brisbane

2005 Thiess Riverprize – Call for Nominations

Detailed information can be found at www.riverfestival.com.au /symposium

PROGRAM 6
RIVER RESTORATION

Program Leader
MIKE STEWARDSON

Report by Brett Anderson, Paul Reich, Mike Stewardson, Ian Rutherfurd, Sam Lake, Gerry Quinn

The Riparian Rehabilitation Experiment

The restoration of riparian zones is being rolled out across streams throughout Australia at significant expense. Time, energy and resources are being committed to increasingly large-scale restoration works, particularly the rehabilitation of riparian vegetation. These efforts are motivated by the assumption that the condition of the riparian zone is intimately linked with the overall health of our streams. In reality, we know very little about the way in which a stream might respond to a rehabilitated riparian zone i.e., how long a specific response might take to occur, what mechanisms might be involved and which factors are useful measures of stream recovery. In most cases the responses of the stream to riparian rehabilitation is not monitored, and where monitoring is conducted no consistent methodology is used. With the support of the Murray-Darling Basin Commission, the CRC for Catchment Hydrology and CRC for Freshwater Ecology have jointly implemented a rigorous experimental program to address this serious knowledge gap (Stewardson, Cottingham, Rutherfurd, and Schreiber, 2004). This is an Associate Project in the River Restoration Program called "The Riparian Rehabilitation Experiment".

The Riparian Rehabilitation Experiment was born from the recommendations of an earlier report to the Murray-Darling Basin Commission (Stewardson, Cottingham, Schreiber, and Rutherfurd, 2002) which included a review of the literature and advice gathered from scientists on the best method of evaluating effectiveness of habitat reconstruction for stream rehabilitation or rehabilitation. The review covered the various methods and strategies of habitat reconstruction in streams, the principles of experimental design for stream rehabilitation studies, and the different ways to assess the success of stream rehabilitation projects. Two principle approaches were identified to test the effectiveness of riparian revegetation: a space-for-time approach; and a dedicated experiment (Stewardson *et al.*, 2004).

Space-for-time substitution (SFTS)

The SFTS method compares existing riparian revegetation sites of different ages. The assumption of the method is that, if we could find enough similar sites that have been revegetated at different times, the difference between the streams at the sites could be attributed to the effect of the vegetation. Put another way, can we use the existing stock of revegetated sites to test the effectiveness of riparian revegetation?

This question was explored by Ezzy (2001). She identified 98 stream frontages in north-eastern Victoria that had been revegetated over the last 30 years. Unfortunately, space-for-time substitution was found to be of limited utility for two reasons:

- Rehabilitation practices have changed dramatically over the last three decades. For example, 30 years ago revegetation with exotic willows and poplars was widespread, and since then many other methods have been used.
- Secondly, the magnitude of between site variability (due to differences in planting density, vegetated width etc.) would probably overwhelm the magnitude of the anticipated riparian impact.

Hence, it was recommended that a dedicated experiment should be established to specifically assess the effect of revegetation and fencing to exclude stock.

Dedicated experiment

We are in the process of setting up a dedicated experiment that is designed to run for at least ten years. The initial experimental design was based on an MBACRI model (Multiple Before After Control Reference and Impact (Downes *et al.*, 2002)). This design meets the so-called 'gold medal' level of evaluation (Rutherfurd, Ladson and Stewardson, 2004), including replicated sampling, replicated control and reference locations, and sampling before and after rehabilitation. However, following an extensive site selection exercise during which 98 sites on 39 streams were assessed (Anderson *et al.*, 2004), three practical issues prevailed:

- True reference sites (i.e. locations minimally impacted by human activity) do not exist on small, lowland streams in the Victorian Murray Basin.
- Few of the permanently flowing (or even semi-permanent) streams have reaches that are devoid of tree cover for more than a couple of hundred metres. Instead the streams within our scope typically host a relatively continuous in-bank tree corridor, albeit with highly degraded or modified understorey and groundcover communities.

- Not all landholders were willing to host a ten year rehabilitation experiment. Most were willing to discuss the merits of revegetation, many expressed concern about pests, weeds and flood-wrecked fencing, and two have so far agreed to revegetate their stream frontage and have fences erected to exclude stock (with one landholder contributing two intervention sites).

Final design

Given these issues, we have settled on a modified BACI design (Downes *et al*., 2002), whereby a pair of control and intervention sites will be located on each stream (Figure 6.1) and a composite reference condition will be derived. Pairs of control and intervention reaches have been established on Faithful Creek in the Goulburn-Broken region, and on Middle Creek and Joyce's Creek in the North-Central region, with a fourth experimental site in negotiation on Major's Creek (GBCMA).

The lack of true reference locations means that, to some extent, the likely end-state of rehabilitation is unknown and unknowable. In place of true reference we are using a multiple line of evidence approach (Downes *et al*., 2002), drawing on historical information, expert advice, and measurements taken at 'best available' (i.e. least degraded) locations.

The principal stages in the experiment are as follows:

- Test sites have been established in multiple catchments in the Victorian Murray Basin, each containing two degraded stream reaches (an intervention site with an upstream control);
- We are in the process of measuring the physical and biotic condition in each control and intervention reach to benchmark their current condition. Measurements at the 'best available' locations are being taken in conjunction with this sampling.
- This spring (2005), rehabilitation of the riparian zone along each intervention reach will be completed. The local Catchment Management Agencies (North-Central and Goulburn-Broken) are providing excellent support - fencing will be erected to exclude stock, and revegetation will be undertaken using tube-stock.
- Monitoring will continue at predetermined intervals as the vegetation at the restored reaches develops and physical and ecological variables respond.

Monitoring design and indicator variables

The overall objective of the experiment is to assess the change in ecological condition of once degraded riparian zones, and their adjacent streams. Within this primary objective, we have designed a monitoring protocol to test a number of hypotheses. These include the following changes relative to control sites:

- Riparian vegetation will increase in diversity and biomass at restored sites
- Stream temperature will be lowered at restored sites in summer and its range will be reduced
- Biomass of selected detritivores (e.g., shrimps) will increase at restored sites
- Fish abundance and biomass will increase in restored sites

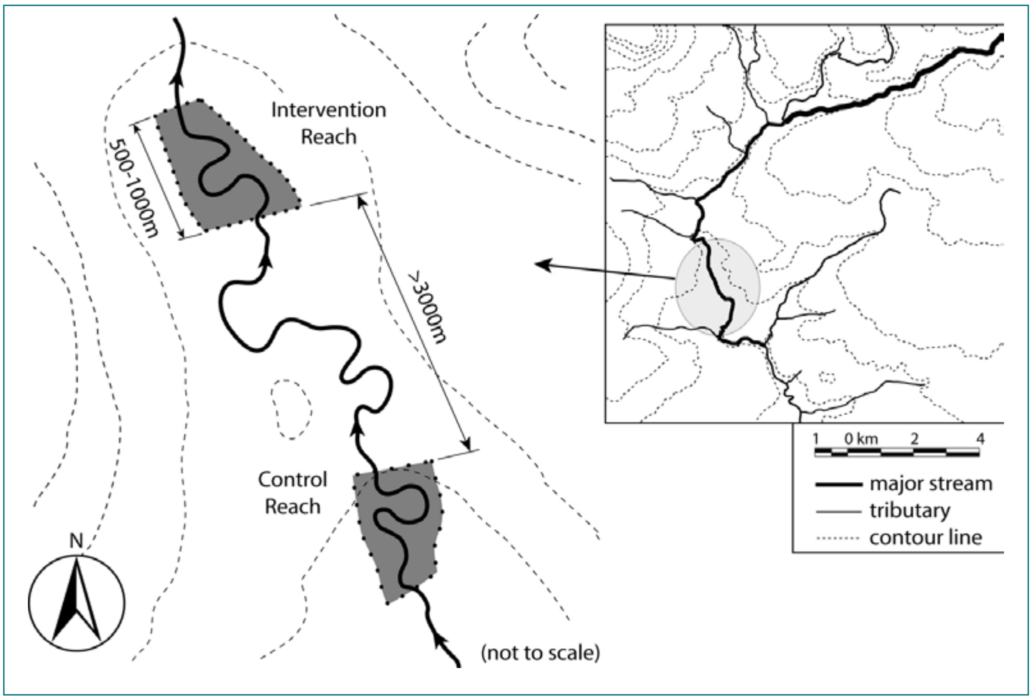

Figure 6.1. Practically realisable layout of intervention and control reaches.

SERIES ON MODEL CHOICE

The Model Choice series is designed to assist you to better understand catchment modelling and model selection. The first publication entitled 'General approaches to modelling and practical issues of model choice' is enclosed with this month's edition of *Catchword*

The second in the series entitled 'Water quality models – sediment and nutrients", is now available for downloading from the Catchment Modelling Toolkit web site at http://www.toolkit.net.au/modelchoice

A printed copy of the second in the Model Choice series will be included in next month's *Catchword*.

Additional printed copies can be obtained by contacting Virginia Verrelli at the Centre Office.

NEW TECHNICAL REPORT

Evaluating the Effectiveness of Habitat Reconstruction in Rivers

By

Michael Stewardson
Peter Cottingham
Ian Rutherfurd
Sabine Schreiber

Technical Report 04/11

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

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

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

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

- Benthic particulate organic matter (pom) levels will rise at restored sites
- Aquatic macrophytes will decrease at restored sites
- Sediment yield from bank erosion will decrease at restored sites
- Nutrient retention will increase at restored sites
- Terrestrial vertebrates (e.g., mammals and birds) will increase at restored sites.

We have designed a monitoring protocol to sample parameters relevant to these hypotheses. The sampling methods employed take in a broad suite of parameters, but in general use low cost techniques that do not require highly trained personnel to implement. It is hoped that our selection of methods ensure that the project remains economical for the long term, while being sufficiently rigorous that meaningful conclusions can be drawn in a decade. Readers interested in finding out more details on the sampling protocol should contact the project team.

Summary and conclusions

The goal of the Riparian Restoration Experiment is to assess the physical and biological effects of riparian revegetation by way of a scientifically rigorous experiment. The experiment we have established follows a modified BACI design. While this may not be as theoretically appealing as the MBACRI model, it is a design that can be put in place in the field. The streams on which we have experimental locations are typical of the small, lowland streams found across the Victorian Murray-Darling Basin. Therefore, the responses measured through this project should be indicative of changes in stream health that will result from the substantial investment being made now in riparian fencing and replanting.

Finally, it is important to remember that just because we know something about the detrimental impacts of clearing riparian zones, does not mean that we can assume that replanting will exactly reverse these effects.

References

Anderson, B. G., Reich, P., Lake, S., Rutherfurd, I., Quinn, G., and Stewardson, M. (2004). The Riparian Rehabilitation Experiment: Evolution of a practical methodology. Paper presented at the Fourth Australian Stream Management Conference, Launceston, Tasmania.

Downes, B. J., Barmuta, L. A., Faith, D. P., Fairweather, P. G., Keough, M. J., Lake, P. S., *et al.* (2002). Monitoring Ecological Impacts: Concepts and practice in flowing waters. Cambridge University, UK.

Ezzy, M. (2001). Evaluating the Effect of Riparian Vegetation on Physical Processes in Small Streams: An investigation of space-for-time substitution in North-East Victoria. Unpublished Honours Thesis, The University of Melbourne, Australia.

Rutherfurd, I. D., Ladson, A. R., and Stewardson, M. J. (2004). Evaluating stream rehabilitation projects: reasons not to, and approaches if you have to. Australian Journal of Water Resources, 8(1), 57-68.

Stewardson, M. J., Cottingham, P., Rutherfurd, I. D., and Schreiber, S. (2004). Evaluating the Effectiveness of Stream Habitat Reconstruction in the Rivers (Technical Report No. 04/11). Melbourne, Australia: Cooperative Research Centre for Catchment Hydrology.

Stewardson, M. J., Cottingham, P., Schreiber, S., and Rutherfurd, I. D. (2002). Evaluating the Effectiveness of Stream Habitat Reconstruction in the Murray-Darling Basin (MDBC Project No. R10008, Stage 1 Final Report). Melbourne, Australia: Cooperative Research Centre for Freshwater Ecology and Cooperative Research Centre for Catchment Hydrology.

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COMMUNICATION & ADOPTION PROGRAM

Program Leader
DAVID PERRY

The Flow on Effect – February 2005

At a glance – a summary of this article

This months article consists of a number of updates across a range of activities involving the Communication and Adoption Program team including Catchment Modelling Toolkit products and upcoming training, the 2005 Catchment Modelling School and the recently published 'Model Choice' series.

eWater bid successful

No doubt many *Catchword* readers will have learned either through this issue's 'Note from the Director' by Rodger Grayson or through their own networks that the eWater CRC bid submitted for Commonwealth funding last year was successful. The eWater CRC builds on the knowledge, end-user networks and business systems of two existing water CRCs: Catchment Hydrology and Freshwater Ecology.

This means that both the CRC for Catchment Hydrology and CRC for Freshwater Ecology will deliver on their milestones by 30 June 2005, after which they will cease to exist. The eWater CRC will commence on 1st July 2005 and will focus on providing business with tools for integrated water management. An interim website containing an overview of the eWater CRC and further information about its research and products will soon be published.

Upcoming Toolkit training

The Catchment Modelling Toolkit training site at www.toolkit.net.au/training is proving to be an excellent tool to assist people to register for Catchment Modelling Toolkit training – particular thanks to Jake MacMullin and Susan Daly for this on-line capability.

Recently four Toolkit workshops were offered during 24-25 February 2005 to complement the Hydrology and Water Resources Symposium in Canberra. The most popular workshop was 'The Introduction to Catchment Modelling and E2', a one day workshop designed to introduce participants to a new way of conceptualising and constructing catchment models. The course started with an overview of catchment modelling and model selection using the concepts of selectable model components and gave examples. Workshop participants then used the E2 catchment modelling framework to construct catchment models of varying complexity to address a range of common catchment management problems at a range of scales. The popularity of course ensures that the CRC will offer it again over the next few months as well as an 'Advanced Catchment Modelling' workshop during the Brisbane and Sydney Catchment Modelling Schools in July.

More training in RAP in Adelaide, and MUSIC (Version 3) in several capital cities is scheduled for April 2005. Details will be sent to all Catchment Modelling Toolkit members who have chosen to receive Toolkit emails and all courses are posted on the training website at www.toolkit.net.au/training when details are finalised. If you wish to receive a specific email prompt for a course then you can register your interest in future courses at the same address.

New Catchment Modelling Toolkit products

Over the last two months there have been a couple of additions and changes to the Catchment Modelling Toolkit website suite of products:

- LUOS (Land-Use Option Simulator) was released on the Toolkit website in late November last year and is designed to help rank land-use change options on the basis of the environmental services provided by the land use change (www.toolkit.net.au/luos)
- WRAM (Water Reallocation Model) was released in early December and is designed to determine optimal water allocation and reallocation in terms of crop planting decisions and irrigation water requirements (www.toolkit.net.au/wram)
- Version 1.2.0 of the SedNet software was released in December last year and the updated version includes the Contributor module which calculates the contribution of each link or sub-catchment to suspended sediment load at a specified point. The update also includes numerous other improvements to the model (www.toolkit.net.au/sednet)

CLASS – publication and downloads

The recently published CRC Technical Report 04/12 by Narendra Kumar Tuteja, Jai Vaze, Brian Murphy and Geoffrey Beale describes the CLASS modelling framework (Catchment Scale Multiple-Land-use Atmosphere Soil Water and Solute Transport Model). CLASS is at the more complex end of the modelling spectrum, but there has been a major effort made to exploit the ever-increasing range of available data for setting up and running the model. It was developed by the New South Wales Department of Infrastructure, Planning and Natural Resources as an Associate Project of the CRC and is a distributed, eco-hydrological modelling framework that deals with water and solute movement from hillslope to catchment scale

SPECIAL PUBLICATION AVAILABLE ON-LINE

Spatial Patterns in Catchment Hydrology

Edited By
Rodger Grayson
Günter Blöschl

This publication (404pp) brings together a number of recent field exercises in research catchments, that illustrate how the understanding and modelling capability of spatial processes can be improved by the use of observed patterns of hydrological response. In addition the introductory chapters review the nature of the hydrological variability, and introduce basic concepts related to measuring and modelling spatial hydrologic processes.

Written in an intuitive and coherent manner, the book is ideal for researchers, graduate students and advanced undergraduates in hydrology, and a range of water related disciplines such as physical geography, earth sciences, and environmental and civil engineering as related to water resources and hydrology.

This publication can be downloaded at no cost from the CRC web site. Follow the 'Special Publication' link from www.catchment.crc.org.au

Three models from the CLASS product group are scheduled for release during early March 2005. Details and downloads for these three CLASS products will be available at www.toolkit.net.au/class shortly after this edition of *Catchword* is printed.

Model Choice Series

The December issue of *Catchword* referred to the CRC's 'Series on Model Choice'. This is a series of publications by the CRC designed to assist industry professionals who are commissioning or involved in catchment modelling to better understand how the tools the CRC is developing will help their business. There are currently two papers in the series entitled "General approaches to modelling and practical issues of model choice" (Paper No.1) and "Water quality model – sediment and nutrients" (Paper No. 2).

Paper No. 1 is included with this issue of *Catchword* and additional printed copies are available from the CRC Centre Office by contacting Virginia Verrelli on 03 9905 2704. Paper No. 2 is not yet available as a printed copy however Adobe pdf versions of both Paper No.1 and No. 2 are also available from the Toolkit website at www.toolkit.net.au/modelchoice

We would appreciate any feedback on this series and how well it meets your needs. Comments and suggestions can be sent to Rodger Grayson (rodger@civenv.unimelb.edu.au) or myself (david.perry@eng.monash.edu.au)

Catchment Modelling School

Plans for the 2005 Catchment Modelling School are well underway. This year we have two Catchment Modelling Schools planned, one each in Brisbane and Sydney. The Brisbane School will be held at Griffith University (Nathan campus) during 30 June to 8 July. The Sydney School will follow at the University of Sydney during 14 July to 22 July 2005. Whilst the 2005 Schools are a few days shorter than the first School held in Melbourne last year, the CRC will be offering almost as many workshops.

Details of the two Schools are being finalised now and expressions of interest in workshops will be sought during mid March. Preference for final workshop places will be given to those who express interest during March. Further information on the School will be available later this month at www.toolkit.net.au/school

Further information

For further information about any of these activities or products please contact me at the number or email address below.

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POSTGRADUATES AND THEIR PROJECTS

Lisa Carpenter

I began a Masters in Engineering Science (Research) in early 2004 under the new Institute for Sustainable Water Resources in affiliation with the Cooperative Research Centre for Catchment Hydrology's River Restoration Program. I am working with Dr Tony Ladson from the Department of Civil Engineering, Monash University and Dr Jane Doolan from the Department of Sustainability and Environment.

I am researching the usefulness of environmental indicators in river management in Victoria. The research is divided into two main areas. The first part of the research will examine and review the use of river indicators in sustainability reporting and waterway management, and the second part of the research will focus on the application of suitable technology and information systems development to facilitate data accessibility and auditing of river indicator information. I will trial a new method of field assessment data collection using digital rather than paper based data entry systems.

So, what are environmental indicators? Environmental indicators are physical, chemical or biological measures that represent or summarise key elements of an environmental system (Neimanis and Kerr, 1996 in Ladson, 2000). They are used to compare condition between a set of locations. For example, the "naturalness" of the hydrological regime in a river can be used as an indicator for river health at different sites in a region. Indicators can be reported in various styles, and various levels of complexity. In Victoria, the formal assessment method for rivers is the Index of Stream Condition (ISC), which is a multi-component indicator. Multi-component indicators such as the ISC use an aggregate of different river health indicators representing the major features of a riverine ecosystem. Each of the sub-indicators has a series of metrics that are scored and weighted to give an overall rating of health.

River managers historically used indicators to report to the public in the State of the Environment formats. That use has now been extended to inform management decision making processes, and to help managers prioritise rivers for management intervention. The recent Victorian River Health Strategy uses river indicators including the ISC to communicate the environmental condition of Victoria's rivers to a wide set of stakeholders. Indicators have also been used in setting broad condition targets for the long term management and rehabilitation of Victoria's rivers. The results of indicator data in Victoria are also directly related to major budgetary decisions made by waterway managers through prioritisation models; for example $23 million dollars is spent annually in the Port Phillip and Westernport region on the Healthy Rivers Program for river rehabilitation and this amount will increase over time (Melbourne Water, 2004). As management strategies are now heavily reliant on indicator data, additional research and auditing processes may be required to calculate data accuracy, standardise results and report on data confidence levels. Auditability is an increasingly important concept in sustainability reporting and means that information management systems used in reporting can be examined both internally and externally for accuracy, completeness, consistency and reliability. Given the increased focus on indicator data for current river management, the benefits and limitations of indicators will be researched with a view to determining the optimum use.

The second part of the research will focus on the emerging use of technology and information systems in the river indicator industry, particularly the use of Geographic Information Systems (GIS), Global Positioning Systems (GPS), satellite imagery, video aerial mapping, and data transfer and reporting through the internet. Advanced data gathering and information systems will be examined for applicability, with a case study in GPS computers for field assessments. The advent of handheld GPS systems that can incorporate sophisticated data entry forms has the potential to shift indicator data management systems in river monitoring to a new level. The shift could integrate higher locational accuracy, data entry efficiency and the GIS mapping of data output for river managers. A new system will be developed to trial GPS computer technology for the field component of the ISC methodology.

Through the research on river indicator use in river management and the associated data systems and advanced technology, I hope to advance the relationship between river monitoring, river management and sustainability reporting.

Ladson, A.R. (2000) A multi-component indicator of stream condition for waterway managers: Balancing scientific rigour with the need for utility. Department of Civil and Environmental Engineering, The University of Melbourne.

Melbourne Water (2004) Draft for Consultation: Port Phillip and Westernport Regional River Health Strategy

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UPCOMING CONFERENCE

Barmah Forest: Indigenous Heritage, Ecological Challenge
18-19 June 2005.
The Royal Society of Victoria

The Barmah-Millewa Forest is an area of great ecological significance and interest. For decades it has been the focus of much archaeological, historical and scientific research. The Victorian Environmental Assessment Council is about to begin its Riverine Red Gum Forests Investigation, after which decisions will be made as to the future of these forests. The conference is a response to the great degree of interest in this remarkable area.

For further information contact tony.ladson@eng.monash.edu.au or download an invitation from www.personal.monash.edu.au/~ladson/BarmahInvite5.pdf

CRC PROFILE

Our CRC Profile for February is:

John Hornbuckle

A little family history

Well, it all started 26 years ago. I was born in a small country town in NSW known as Narrandera which lies on the banks of the Murrumbidgee River. My great grandfather first came to Australia to work on the irrigation canal which takes water from the Murrumbidgee River and diverts it for irrigation in the Murrumbidgee Irrigation Area around Leeton and Griffith. He had a horse and dray team that carted rubble and rocks and dug out sections of the artificial canal around Narrandera. Both my father and grandfather worked locally for the State Forest Commission of NSW (I can't keep up with what it's now called!). My grandfather was a bushganger and my father is a nursery foreman still to this day. As a kid this meant I was usually able to tag along for rides on weekends whether monitoring for bushfires or patrolling for illegal woodcutters, which provided some real eye opening times and gave me a love of the outdoors. Until I was about twelve years old, we lived on-site at the Narrandera State Forest Nursery. Everything had to be watered over the summer months and it was usually a significant part of the weekend during summer. So from a young age I received a good grounding in the importance of the land and water, which our everyday lives rely upon.

Schooling, university and work

I was lucky to find school interesting and did well enough to get into university. I completed an environmental engineering degree at the University of New England in Armidale, had an excellent time and thoroughly enjoyed the experience. During my third year, I applied for a summer studentship being offered by CSIRO Land and Water in Griffith and found the research and work environment to be excellent. Seeing drainage and weighing lysimeters in action, large scale projects like the Serial Biological Concentration scheme, FILTER and regional water balance studies being carried out in areas as far away as Pakistan, India and China really gave me the feeling that this was a great place to be to conduct research that impacted not just locally but all over the world. I managed to finish the summer studentship report on collating soil physical property studies undertaken over the last 50 years in the MIA and CIA and following that, an opportunity came up to do an honours project on improving surface irrigation design and management through simulation modelling. This started me on a modelling path. After finishing my undergraduate degree I applied for the NPIRD Land and Water Australia scholarship to do my PhD which focused on investigating the impact of subsurface drainage design and management on salt load generation and ways off minimising generation of saline drainage at the farm level. This gave me the opportunity to do lots of field water and salt balance studies and have some neat field sites to undertake research. During the three years of the PhD, I managed to spend a total of 43 nights camped in a retro fitted caravan which doubled as temporary home and portable lab next to a drainage sump measuring everything from evapotranspiration to subsurface drainage flows. Eventually I managed to get some reliable dataloggers up and running and then spent all the free time I had gained developing some analytical models of alternative drainage design to minimise salt loads from subsurface drainage systems. I finished my PhD during 2003 in a little over three years, after spending some time midway through at Colorado State University. This work involved looking at irrigation salinity issues at a regional level with modelling tools such as GMS. During my time in the USA I developed a real appreciation for how blessed we are in Australia to have such good quality irrigation water. A tribute to our catchment managers and something I hope groups such as the CRC for Catchment Hydrology can strive to maintain for future generations. Travel around southern Colorado and Arkansas and you begin to see the impacts of decades of non-optimal water management and large scale issues with land salinisation.

In late 2003, a job opportunity came up to work as a post doc on the 2A Project "Minimising the Impacts of Irrigation and Drainage on River Water Salinity" and I jumped at the chance to become involved in the project. Considering that in most cases irrigation accounts for 80% of the consumptive water use of a catchment I feel the project is critically important. It will deliver a great deal to regional water managers and planners involved in predicting the impacts of irrigation on river systems and also in developing management scenarios and policy guidelines for irrigation areas which reduce downstream impacts. At the moment we are busy developing a module to capture irrigation return flows (volume and salinity) for E2 which should be ready in early 2005. This keeps me busy for 80% of my time and the remainder is spent quantifying evapotranspiration from vineyards using energy balance instrumentation. The data will be used to benchmark peak daily water use for the design of pressurised irrigations systems. I still manage to get a little time in the field which keeps me sane.

Home front

On the personal front I have just celebrated the birth of my first child Jack, in July, with my partner Wendy who's a water quality scientist and have been busy 'bonding' with the little guy. I also play rugby for the local second grade team, the Griffith "Blacks", which keeps me moderately fit (well I try to kid myself it does) and I enjoy the odd spot of camping, fishing and canoeing when I get the chance.

So that's pretty much my story, well the first 26 years anyway. Hopefully in the next 26 I can continue to work on stimulating research problems and help find ways to sustainably feed the predicted 10 billon people which will live on our planet while still protecting our natural resource base – a challenge for everyone! I'm sure finding ways to better manage and design our irrigation systems will be a large part of meeting this objective and I hope to play a small role in achieving this endeavour over the future years.

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WHERE ARE THEY NOW?

Report by Margaret Gooch

I took up the offer of a CRC scholarship in July, 2000, and began my study soon after. My doctoral thesis, undertaken at Griffith University in Brisbane, was completed in December, 2003. It was concerned with understanding the contributions that volunteers make to integrated catchment management. This was achieved through a phenomenographic study of volunteers conducted along the east coast of Queensland. This multi-disciplinary study combined social, cultural, economic and ecological aspects of stewardship.

I would like to express my thanks to the CRC for its fantastic support during my study, and for the opportunities that I was lucky enough to pursue during that time. Highlights of my study included participation in the 6th International Invitational Research Development Seminar on Environmental and Health Education, Budapest, Hungary June 2002. This was a small invitation only seminar on best practice in environmental and health education. During one of the three days, I led a half-day session with Dr Debbie Heck (Griffith University) to investigate the links between social learning, social capital and sustainability.

As well as being funded by the CRC Catchment Hydrology, I was affiliated with the Citizen Science program of the CRC for Coastal Zone, Estuary and Waterways Management. The results of my study contributed to a joint-CRC on-line toolbox of resources, strategies and case studies related to community education and public participation in natural resource management (the Citizen Science Toolbox).

Currently, I am working within the Sustainable Mining group of CSIRO's Division of Exploration and Mining. I am employed on a part-time basis as a post-doctoral fellow undertaking research on societal uptake of new technologies based on coal mining. In this capacity, I work with physicists, engineers and computer modellers developing communication strategies for a range of stakeholders with an interest in low emission technologies. I also teach at Griffith University one day a week, and have two active and growing sons, a dog and a husband to look after! All in all, life's pretty hectic.

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OUR MISSION

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

OUR RESEARCH

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

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

CRC AUSTRALIA

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

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

Associates:
Water Corporation of Western Australia

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

Industry Affiliates:
Earth Tech
Ecological Engineering
Sinclair Knight Merz
WBM

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