NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

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A NOTE FROM THE DIRECTOR

Professor Rob Vertessy

Inside...

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

THE PUBLIC POLICY SETTING FOR AUSTRALIAN LAND AND WATER MANAGEMENT

Land and water management is now a prominent public and political issue, evidenced by the unprecedented level of media coverage in recent years. Virtually all levels of government, and most of the community, now agree that our water systems (including rivers, lakes, floodplains, wetlands, estuaries and groundwater) are under threat and that profound public policy changes are required if we are to manage these resources in a sustainable way. Implementing such change will require a whole-of-government approach, requiring significant community input and robust scientific knowledge to underpin what will be a series of difficult planning and management decisions.

The National Water Initiative

In 1994 the Council of Australian Governments (COAG) agreed to a Water Reform Framework to be implemented by 2001. The key elements of the framework included pricing reform, clarification of property rights, allocation of water for the environment, adoption of trading arrangements for water, institutional reform, and public consultation and participation. This initiative was complemented by further COAG agreements in 1995 on competition policy with significant implications for the water industry, including public monopolies in water.

Almost ten years on, COAG have declared these initiatives to have achieved modest successes and called for a re-doubling of efforts. In August 2003, COAG announced its intention to 'Increase the productivity and efficiency of water use, sustain rural and urban communities, and ensure the health of river and groundwater systems'. In COAG's view, this can only be achieved by 'Improving confidence in the economic framework for water resource management which is underpinned by environmental water provisions and better management of environmental water'.

COAG's proposed vehicle for realising these objectives is the National Water Initiative (NWI), which will secure water access entitlements, expand water markets and trading, ensure ecosystem health and encourage water conservation in our cities. The COAG Senior Officials Group on Water has identified the need for significant R&D to achieve these goals.

Other key policy initiatives

The National Water Initiative builds upon a foundation of other important natural resource management strategies, including the National Action Plan, the Natural Heritage Trust, the Coastal Catchments Initiative, and the Living Murray. Though largely administered by the Commonwealth, these initiatives depend strongly on the States and various regional management groups for implementation. In addition, several States and capital cities of Australia have announced their own strategic plans to reform land and water management. Prominent examples include the Melbourne Water Resources Strategy, Waterproofing Adelaide, and the Reef Water Quality Protection Plan. Collectively, these and other strategies entail enormous public investment and far-reaching consequences for public utilisation of land and water resources and the impact of this on the environment.

Where our CRC can help

There is a high degree of congruence between these strategies, and the forthcoming COAG National Water Initiative will undoubtedly unify many of the strategies' objectives and provide an even stronger impetus for change. Now, more than ever, those developing policy and implementing it have a need for greatly improved knowledge and tools for use in their work to secure improved land and water management outcomes for Australia.

Our view is that decision makers need analysis tools to make rational and defensible choices in the complex, uncertain and multi-objective world of catchment management, and the means of including the community in the choice process. Our CRC's primary niche is the development of such tools to assist government to anticipate the impacts of land-use change, land management, river management, and climate variability and change, on catchment water and material balances (in rural and urban contexts). With the help of the CRC for Freshwater Ecology, this predictive capability is being extended to account for resultant impacts on riverine ecosystem condition. Finally, our ground-breaking work in experimental economics provides a means of laboratory testing alternate policy strategies (such as regulatory control and market-based instruments) designed to yield specified social, economic and environmental objectives.

We regard the delivery of our CRC's predictive capability to land and water managers as an essential first step in the development of sound public policy

CRC PUBLICATIONS LIST

A complete list of all documents and products produced by the CRC since 1993 is available at our web site at www.catchment.crc.org.au/publications

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aimed at improving the utility of our land and water resources. Our CRC is eager to assist the Commonwealth, State governments, urban water managers and regional catchment management authorities with the implementation of the National Water Initiative when it is launched next year.

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
GEOFF PODGER

Report by Geoff Podger

Modelling water regulation Part II

Introduction

In the September *Catchword* I wrote an article that discussed how river basin models model river regulation. I had covered relatively simple systems with single storages, in that article. I suggested that I could discuss more complex systems in a future *Catchword*.

This article discusses processes that need to be considered when modelling regulated river systems with multiple storages both in parallel and series. Various types of water regulation accounting systems are also outlined such as annual accounting, carry-over, continuous accounting and capacity sharing. The sharing of water resources between multiple states/countries is also noted.

Storages in series

In many regulated river systems there are multiple storages. When storages regulate water downstream to other en-route storages then the storages are in series. The way that these storages are operated in systems can vary greatly depending upon the size of the storages, the location of the storages, the location of the water users and operational policies.

Large storages are used to supply water users and small storages are used to re-regulate surplus or meet shortfalls in the river. Models need to allow users to be supplied from a particular storage but supplemented by other intermediate storages. Models need to allow intermediate storages to order from upstream storages to meet rule curve, and outlet constraints. Storages will need to place orders in advance to upstream storages such that downstream orders can be released or met. The orders need to take into account delivery time, in-stream storage losses and transmission losses. The storages in models need to re-regulate surpluses for efficient river operation.

Some water users in the regulated system may be supplied by one storage while others are supplied by multiple storages. The access of different water users to storages needs to be taken into account. In some cases users will be supplied directly by a storage and in other cases they will be supplied indirectly. Where water users are supplied indirectly by a storage, the release of the order needs to coincide with when the water user is expecting the water. Consequently orders need to take into account travel time differences between supply reservoirs and re-regulating storages.

There are a host of operational policies including transfer constraints, rule curves, high security reserves and environmental releases. In some cases the models need to project storage volumes months in advance to determine when transfers between storages should occur.

Storages in parallel

There are other regulated systems where reservoirs are located on different river branches such that they cannot supply water to the other storage, but either storage can supply water to downstream water users. These systems are known as having parallel storages. The operational rules in these systems need to take into account the joint operation of the storages when supplying downstream water users. Some water users may only be supplied by one of the storages while others may be supplied by both.

Generally, operational rules for storages in parallel relate to achieving an equal probability of spill between the storages. For example, if the storages are of similar size but one receives more inflow, on average, more orders will be passed to this storage. Models will need to adjust which branch orders pass up based upon the storage volume in each system. In some systems the supply branches may have channel or release constraints that will influence how the orders are passed to each storage.

Of course in many systems there are combinations of storages in both series and parallel. An example of such a system is the Border Rivers System, which is located on the border between NSW and Queensland. In this system there are three storages in parallel, Glenlyon, Pindari and Coolmunda Dams. The Coolmunda Dam only operates as a parallel system part of the time, the rest of the time it operates as an independent system. The system also has a re-regulating weir at Boggabilla which operates in series with the three upstream storages.

Annual accounting

The accounting and sharing of water resources within a regulated river system (dam and useable tributaries) on an annual cycle (usually July to June in NSW) is known as annual accounting. The water manager makes regular announcements on the percentage of users' entitlement that is available for use.

The amount of water available to users is assessed as the active volume in storage plus any water use since the start of the water year, estimated recession inflows, supplementary downstream tributary inflows and expected minimum inflows from now until the end of the water year. Then high security requirements, reserves, operational losses, estimated evaporation losses and transmission losses are deducted from this total. The remaining volume is then divided by the active entitlement in the valley and multiplied by 100 to determine the allocation announcement. This proportion constrains the proportion of general security users' entitlement that may be used in a water year.

At the end of the water year any unused entitlement is socialised and reallocated to all other water users at the start of the next water year. This requirement causes many water users to order entitlements near the end of water year to fill on-farm storages and soil moisture profiles, so that the water is not reallocated to other water users.

Carry-over

Ordering water at the end of a water year to store in on-farm storages or soil water profiles is a very inefficient practice as much of the water is subsequently lost in evaporation. To avoid this practice, water management authorities introduced carry-over, which allowed water users to retain a proportion of any unused allocation. When modelling carry-over, individual's carry-over needs to be maintained in an account that may be constrained to a maximum – this may be a proportion of the entitlement or a valley wide maximum. The carry-over may be subject to a discount rate and will get used prior to the current year's allocation. If any or some of the storages in the system spill, then the carry-over water may be forfeited.

Continuous accounting

The next progression from annual accounting with carry-over is continuous accounting. Continuous accounting is like annual accounting with carry-over, where the carry-over has a maximum limit but no reset or discount rules applied. Another way of looking at it is that each water user has a defined share of the storages in a system which is a proportion of their entitlement. This share of the storage is maintained by that user. There is also a share for the socialised water that is required for high security users, reserves, evaporation losses, transmission losses and operational loss.

The way that this is modelled is that a proportion of all the storages is set aside for river operation. Then the remaining active capacity of the storages is divided up in proportion to the entitlements in the valley. For example if the total storage in the system is 1000GL and the licenses in the system are 400 GL, then if 20% of the storage is set aside for socialised water the remaining

NEW TECHNICAL REPORT

Estimating Water Storage Capacities in Soil at Catchment Scales.

By

Neil McKenzie
John Gallant
Linda Gregory

Technical Report 03/3

Landscapes vary in their capacity to store water. Estimates of water storage capacities in soil are required to allow a better analysis of interactions between vegetation and stream flow from local to regional scales. This is particularly relevant to simulation studies relating to dryland salinity, farm forestry and water security. This report investigates how land resource data can be used to improve estimates of water storage capacities in soil at catchment scales.

Printed and 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 .pdf file.

Visit www.catchment.crc.org.au/ publications and search under 'Land-use Impacts on Rivers'

www.toolkit.net.au

The Catchment Modelling Toolkit web site continues to expand. The Toolkit web site will be used to deliver the CRC for Catchment Hydrology's modelling software and supporting documentation over the next three years.

Members of the Toolkit web site can now download the River Analysis Package (RAP) and the Rainfall Runoff Library (RRL) by logging in and visiting:
www.toolkit.net.au/rap
www.toolkit.net.au/rrl

More software products will be available to download from the Toolkit site over the coming months, so keep an eye on www.toolkit.net.au

For further information visit www.toolkit.net.au

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800 GL is shared amongst the remaining water users i.e. their storage capacity is twice their entitlement.

Capacity sharing

Capacity sharing is the next progression from continuous accounting where water is not socialised and each user has a share that will be debited not only for the water received at the farm gate but also the delivery losses to get it there. This type of system is extremely complex as shares of tributary inflows and re-regulating storages are very difficult to determine as it is a function of where a water user is located in the system. It is extremely difficult to determine a share size that ensures a similar level of security for all water users as compared to continuous accounting. This sort of water management is not applied to individual water users but may be applied to groups of water users i.e. high security, general security and the environment. It may also be applied to states or countries.

State/Country sharing

Water management systems such as the Border Rivers and River Murray span multiple States. Due to this, these systems have to be managed for multiple States, where the different States have shares in the storage, tributary inflows and delivery system. States may operate their share of the system differently.

Issues that need to be considered in managing these systems are:

- Portioning of storages that allows for State identity of water such that only a State's water will flow into a State's share until that State's share is full. (Then that water will get redistributed to the other State in proportion to their share in the storage and their capacity to store that water (internal spill)).
- State identity to downstream tributary inflows both for supplementing regulated supplies and surplus distribution.
- State identity for losses and water that moves into effluent systems.

There are various ways of sharing surplus between States, either not sharing at all, sharing with a payback arrangement in head water storages through to sharing without payback.

Building models to be able to cope with this can be quite complex and models such as IQQM and the Murray Simulation Model (MSM) have this capability.

Conclusion

Water management in Australia is extremely complex and this is mainly driven by the scarcity of water resources. Complex management rules have been developed over time to ensure shares for the environment, and equity for other water users. The rules ensure the most efficient use of water within our systems. This is probably why the water management capabilities of Australian industry models such as IQQM, MSM and REALM are far more advanced in comparison with equivalent overseas models.

The TIME catchment model will need to include the capabilities of the industry models. This is not an easy task as the code associated with managing rivers is quite complex to write. I have spoken about our strategy for doing this in previous *Catchword* articles. We are currently looking at the data structures that will be required in TIME to allow the development of this code.

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PROGRAM 2

LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Report by Evan Christen, John Hornbuckle and Matthew Bethune

Project 2.19 (2A) Reducing the impacts of irrigation and drainage on river water salinity

Hydrogeological settings of irrigation areas and their impacts: A mixed bag

Irrigation has a large impact on catchment hydrology. This is particularly the case in the Murray-Darling Basin (MDB), where 60% of natural river flows are diverted for irrigation. Project 2.19 (2A) aims to provide information and models that will enable the inclusion of irrigation impacts on river water quality in the CRC for Catchment Hydrology Modelling Tookit. However, the hydrology of irrigation areas varies dramatically across the Australian environment, from coastal plains (eg the Burdekin Delta) to Riverine alluvial floodplains (eg Murrumbidgee and Shepparton Irrigation Areas).

To undertake appropriate modelling a conceptual framework is required that captures the impact of the hydrologic setting on the water and solute pathways into and out of irrigation catchments and consequently, the impact of irrigation on river ecosystems.

The major irrigation areas in Australia have been broadly grouped into four conceptual hydrologic settings:

1) Riverine plain

2) Incised river

3) Upland

4) Coastal plain

Riverine Plain

Irrigation on an alluvial riverine plain (RP) is probably the dominant hydrogeological setting for irrigated areas in the world, e.g. Indo-Gangetic plains, Yellow River basin, San Joaquin valley and the Riverine plain in SE Australia. These areas are generally the easiest to irrigate, being relatively flat and able to be commanded by gravity from the river. This allows for gravity distribution of the water across the landscape in open channels and flood irrigation techniques to apply the water to the land.

The hydrogeology of the riverine plain is characterised by unconsolidated alluvial deposits ranging from sands to silts and clays. The sedimentary sequence is complex and changes with depth. Often deeper sediments are coarser grained and the mixtures of clays and silts in the upper layers are interspersed with small quantities of sands and gravels. These are in many cases associated with paleochannels of ancient rivers and streams. The sediments in alluvial plains are generally of considerable depth, ranging from 100-200m in smaller systems to several hundred meters in the massive river systems of the Indo-Gangetic plains. Groundwater quality is usually variable, from fresh water close to river systems, to very saline at a distance from rivers.

Upland

Upland irrigation systems, as the name implies, are in the upper parts of catchments, rather than the lower flood plains. The soils are developed in situ from the weathering of the parent material, such as in the Burdekin River Irrigation Area. The depth of soil is shallow (tens of meters) and groundwater systems are small. These groundwater systems maybe contiguous with groundwater in the bedrock material e.g. fractured rock aquifers. Groundwater systems may be small due to poor lateral connectivity due to bedrock highs, faulting or dyking. This leads to small /stagnant groundwater systems which may be fresh or saline.

Incised River

Incised river (IR) systems such as the Lower Murray represent a very different hydrogeological setting to the previous systems. In these cases water is pumped up from the river and leakage below the root zone will return to the river via the groundwater system. The IR system can have high rates of recharge as there are large hydraulic gradients to the river and deep unsaturated zones of relatively permeable materials. The groundwater under these systems in Australia is usually highly saline

Coastal Plain

These irrigation systems are flat areas by the coast, underlain by sedimentary rocks and alluvial and coastal sediments sourced from the hills/plateau, e.g. Burdekin Delta . These systems typically have relatively permeable aquifers and silty soils. The groundwater is generally of low salinity but seawater intrusion can be the major problem when pumping groundwater for irrigation.

Relating impacts to hydrogeological settings

Each of these types of irrigation systems has different hydrological attributes, management issues and impacts on rivers. Discharge of saline groundwater or surface

MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

A Critical Review of Paired Catchment Studies with Reference to Seasonal Flows and Climatic Variability.

By

Alice Best
Lu Zhang
Tom McMahon
Andrew Western
Rob Vertessy

Technical Report 03/4

This report focuses on the use of paired catchment studies as a means for determining long-term changes in water yield as a result large scale changes in vegetation. Current knowledge gaps in relation to the impacts of broad scale vegetation changes on flow regime and seasonal flows are highlighted and possible methods of addressing these gaps are suggested.

This report is available as an Adobe .pdf file only.

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MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

Impact of Increased Recharge on Groundwater Discharge: Development and Application of a Simplified Function using Catchment Parameters.

By
Mat Gilfedder
Chris Smitt
Warrick Dawes
Cuan Petheram
Mirko Stauffacher
Glen Walker

Technical Report 03/6

This report describes the development of a simple approach towards estimating the response of groundwater systems to changes in recharge that arise from changes in land-use. The emergent properties of a groundwater system are examined using scaling arguments, by combining the effect of aquifer properties into a single dimensionless groundwater system similarity parameter (G).

This report is available as an Adobe .pdf file only.

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drainage water will directly impact on river water quality. River flow and salinity will also be affected as a result of recharge to the groundwater system. Table 2.1 summarises the relative importance of some of the major environmental issues associated with irrigation in the different hydrologic settings.

When trying to undertake hydrological modelling and determine biophysical resource policy in irrigated areas, it is necessary to understand the different hydrogeological settings and how these affect the impact irrigation has on groundwater and river systems. While this step is close to completion, the challenge is now to develop a generic modeling framework within EMSS which can be used across such broad hydrological settings whilst adequately describing the major processes and impacts.

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Table 2.1. Relative importance of some environment issues under the different hydrologic settings, ranking is High (H), Medium (M) or Low (L).

Setting	Groundwater discharge to river	Groundwater recharge from river	Surface return flows	Soil salinisation	Groundwater salinisation
Riverine Plain	M	M	H	H	L
Coastal Plain	L	M	L	L	H
Upland	L	L	H	H	H
Incised River	H	L	L	L	L

PROGRAM 3

SUSTAINABLE WATER ALLOCATION

Program Leader
JOHN TISDELL

Report by Ilan Salbe

Murrumbidgee IQQM Modelling – Past, Present and Future

The Valley

The Murrumbidgee valley is one of the great utilisers of Murray-Darling Basin (MDB) water resources. Some 2200 Gigalitres (over 2 million Olympic swimming pools) are diverted for irrigation purposes annually in the valley from the Murrumbidgee, Yanco, Colombo and Billabong rivers and creeks. This makes up something of the order of forty percent of New South Wales MDB irrigation usage. A scale perspective to this usage is that Sydney, with a population of about 5 million, uses an annual average of about 600 Gigalitres. That means that Murrumbidgee valley irrigation usage is almost four times that of Sydney.

Around 80,000 hectares of rice is grown each year and, with rice water usage at around 14 Megalitres per hectare, rice is by far the dominant crop water user with over 1000 Gigalitres annually. An unusual feature in the valley is the flood bay irrigation in the Nimmie Caira system of the Lowbidgee district. This method of irrigation involves opportunistic filling of large bays, during Murrumbidgee River high flow events, for a period of four to six weeks to saturate the soil profile. The water is then moved off to downstream bays. The present clay soil, under the normally very hot climate, then seals in the moisture. A rainfall event in the seasonal window then triggers the planting of one of the system's two deep-rooted crops, safflower and wheat. No further irrigation takes place, with the crops water requirement being satisfied by rainfall and the water present in the soil profile. This method of irrigation requires no usage of herbicides for weed killing, which allows the district to be a major organic producer.

A more detailed description of the valley and the CRC for Catchment Hydrology activities related to it can be found in 'The Murrumbidgee Catchment' by Peter Hairsine and Carolyn Young (*Catchword*, October 2001) and 'The Murrumbidgee Focus Catchment' by Carolyn Young *et al* (*Catchword*, December 2002).

Murrumbidgee Modelling

The focus of this article is the past, present and future of the daily time step Murrumbidgee Integrated Quantity Quality Model (IQQM) and its monthly time step predecessor. The monthly "Murrumbidgee Valley Irrigation Model" was first developed in the late 1970s by the predecessors to the current Department of Infrastructure, Planning and Natural Resources (DIPNR). It was still in use, under the stewardship of Paul Pendlebury of DIPNR's Centre for Natural Resources (CNR) in the late 1990s, when the Murrumbidgee River Management Committee (MRMC) was devising the environmental flow rules (EFRs) which are basically still in use today. Those rules included a set of very complex environmental accounts and Burrinjuck translucent dam release rules (rules which set a minimum dam release as a function of dam inflow). The complexity was required to achieve an environmental outcome which minimised high year impacts with the consequent severe socio-economic impact. The monthly model proved to be good at assessing the resource implications of the EFRs, but the monthly time-step limited analysis of peak flood flow inundation analysis and other inter-month attributes.

Limitations of monthly models

It was recognised five years previously by the DIPNR modelling group that monthly time step models had inadequacies in their abilities to assess environmental flow rules and supplementary flow access periods (off allocation periods where irrigation diversion is not counted against irrigator license volumetric limits). The DIPNR group thought it necessary to switch from a monthly to a daily platform. A world wide quest for a suitable daily time-step modelling platform was undertaken. The conclusion was made that no such platform existed. However the search did unearth a number of models with differing desirable attributes. That gave birth to the idea of the IQQM shell architecture, which allowed for the gathering and incorporation of the best aspects of available software.

Planning for 1QQM

Planning for a Murrumbidgee IQQM started in the mid-90s. Because of inadequate resourcing, development was somewhat stop-start. In about 1999, a continuous development phase commenced which culminated in the use of the model for the Murrumbidgee Water Sharing Plan (WSP) process. That WSP process involved the MRMC making recommendations to the NSW government for a set of irrigation/environment resource sharing rules which would remain unaltered for a period of 10 years. The idea being that such a prolonged period of rule stability would give some certainty to farmers' investment decisions. The MRMC recommendation was largely accepted by government and the Murrumbidgee WSP was gazetted in December 2002. The plan is due to come into usage on 1 July, 2004. From a modelling viewpoint, the Murrumbidgee IQQM was adequate in terms of supplying information

MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

Modelling the Effectiveness of Recharge Reduction for Salinity Management: Sensitivity to Catchment Characteristics.

By

Chris Smitt
Mat Gilfedder
Warrick Dawes
Cuan Petheram
Glen Walker

Technical Report 03/7

This report describes the use of modelling to investigate the sensitivity of groundwater and other characteristics on the effect of recharge reduction on salinity management.

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Visit www.catchment.crc.org.au/publications and search under 'Land-use Impacts on Rivers'

MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

Testing In-Class Variability of Groundwater Systems: Local Upland Systems.

By

Cuan Petheram
Chris Smitt
Glen Walker
Mat Gilfedder

Technical Report 03/8

This report assesses the extent information can be transferred between hydrogeologically similar catchments, by investigating in detail one set of similar catchments.

This report is available as an Adobe .pdf file only.

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to the MRMC on the daily flow consequences of the EFRs, especially those related to wetland inundation periods for the Wagga to Narrandera reach. The Murrumbidgee IQQM was however inadequate in terms of saying anything about the EFRs effects on fish, bird breeding, riparian vegetation etc.

Murrumbidgee IQQM Model – Other Uses

The Murrumbidgee IQQM is used for auditing of the MDB cap on diversions to 1993/94 levels of development. The auditing is facilitated by the building of the Murrumbidgee "cap model" which provides 1993/94 level of development diversions for a given climate daily sequence of rainfall, evaporation and river inflows. In simplistic terms, the cap model is an "equation" in which the "y" is 1993/94 level of development diversions and "x's" are rainfall, evaporation and tributary inflows. That cap model is used to estimate cumulative cap diversions using actual climatic data from 1 July, 1997 , the commencement date for cap auditing, to the end of the last completed water year (30 June 2003 at time of writing). Those cap model diversions are compared with actual cumulative diversions. If actual diverions are significantly higher than cap diversions, then that is a signal that a cap breach may have occurred. Other procedures too detailed to mention here then take place.

Two other uses over the last eighteen months are noteworthy. The first is related to the Murray-Darling Baseline Salinity Management Strategy (BSMS). That strategy spells out the need for linked MDB valley models capable of predicting the effect of an action somewhere in the MDB, such as a new salt interception scheme or a land-use change, on the salinity levels at Morgan, South Australia, a downstream point on the Murray. Morgan salinity changes, estimated using the linked models, act as a consistent barometer of the impact of actions anywhere in the MDB. A report on the incorporation of salinity into the Murrumbidgee IQQM model is currently being written and the model is anticipated to be used in the BSMS by March, 2004

The second use is related to the Living Murray process, That process is aimed at improving the health of the Murray river and its environmental assets such as the Murray Mouth, Chowilla wetlands, and the Barmah forest The Murrumbidgee IQQM has been used to test options related to the Murrumbidgee river yielding extra flow (at Balranald and Darlot) to the Murray. One desirable feature of this work was the use of the MFAT software (see below) to gauge the environmental benefit of the extra flows to the Murray as they worked their way down the Murrumbidgee system.

The Future in Brief

In modelling there is always a gulf between reality and its representation in a model. The degree to which that difference matters depends on the questions being asked from the model. One trend evident in recent years is that more and more is being asked from models. That in turn means that the reality / model gap needs to be narrowed with more processes being represented. Murrumbidgee modelling actvities in recent times have shown the demand to better represent the processes of water trading and farmer planting decision making (in the Murrumbidgee this includes trading between the Murray and Murrumbidgee), crop yield accounting, river-floodplain-groundwater interactions, salt mobilisation and transport processes and finally, ecological assessment.

The CRC for Catchment Hydrology activities complement these demands, The work being led by John Tisdell and Bofu Yu in Project 3.08 (3A) will lead to IQQM making "theoretical economic rationale" crop planting and trading decisions. Currently in IQQM this is done in an empirical fashion. This works reasonably well until question are raised such as "what would happen if the rice market price dropped significantly?" The maturing nature of the trading market in the Murrumbidgee puts a greater emphasis on the trading modelling issue.

The activities in Project 2.21 (2C) being led by Mark Littleboy will lead to a better representation of current salinity mobilisation processes. As for the economic aspects, empirical methods exist to model these but they do not provide for a means of modelling the consequence of landuse change on mobilisation.

Relevant research is also being carried out outside the CRC for Catchment Hydrology. Robyn Watts at Charles Sturt University has applied the Murray Flow Assessment Tool (MFAT) developed by CSIRO to assess the ecological consequences of Living Murray scenarios. John Norton, Graeme Dandy and Tony Jakeman are looking at the issue of uncertainty associated with model predictions. An area where demand is drawing more attention. There is obviously much, much more.

The DIPNR Workers and Other helpers

Andrew Davidson has been involved in Murrumbidgee thinking, modelling and coding (monthly and daily) for over six years. Stephen Roberts has been involved for four years. Robert O'Neill and Geoff Podger have passed on their IQQM modelling knowledge and experience. Paul Simpson is an authority on the Murrumbidgee Valley and has always been happy to advise. David Nicholls and Hemal Jayawickrama have helped on operational matters. Staff from Coleambally and Murrumbidgee Irrigation have given time to provide data and advice. Department of Agriculture agronomists have been happy to advise on crop and farmer behaviour matters. There have been many other contributors as well. They have all combined to progress the state of the art. However there is still a long development path ahead to answer the increasing demands of a more sophisticated valley. Exactly how that will occur? Perhaps TIME will tell?

Please note that time constraints in writing this article undoubtedly have meant that some minor inaccuracies have sneaked through. I am particularly concerned that credit may not have been given to those who deserve it. Please forgive that.

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PROGRAM 4

URBAN STORMWATER QUALITY

Program Leader
TIM FLETCHER

Report by Tim Fletcher, Ana Deletic, Matt Francey and Sean Moran

Uncertainty in water quality sampling: how many events to sample?

Stormwater quality monitoring

Many millions of dollars are invested in the management of stormwater in Australia, with the aim of protecting receiving waters – be they streams or bays – from the impacts of urbanisation. The prioritisation and design of stormwater treatment measures depends on the quality of water emanating from upstream catchments (Fletcher *et al.*, 2001). Consequently, researchers in the CRC are working to be able to better predict the quality of water, in relation to catchment characteristics, so that stormwater management strategies can be well-targeted.

The Victorian EPA, through the Victorian Stormwater Action Program, has provided funding to undertake an ambitious monitoring project, which aims to predict stormwater quality using short-duration climate data, combined with catchment surface or land use information. However, monitoring (and associated laboratory analysis) is very expensive. Consequently, any monitoring program should take just enough samples to confidently describe the statistical behaviour of the underlying water quality in the catchment of interest.

Objectives

The purpose of the analysis presented in this paper was to determine how many storm events we should sample in order to record natural variability of Event Mean Concentration (EMC) within one catchment.

Whilst the objective of the study is to help in the design our monitoring program in Melbourne, the findings provide important guidance to any organisation wishing to collect stormwater quality data. It is important to minimise the required costs but not lose important information. This analysis is also the first step in attempting to quantify the uncertainty associated with stormwater model outputs, such as those from MUSIC. For stormwater models that use the statistical properties of water quality parameters (e.g. the means and standard deviations of TSS, TP or TN), the level of uncertainty associated with these parameters is directly linked to the quality and amount of the stormwater data available for their calibration/verification.

MDBC-CSIRO-CRC TECHNICAL REPORT SERIES

Assessment of Salinity Management Options for Kyeamba Creek, New South Wales: Data Analysis and Groundwater Modelling.

By

Richard Cresswell
Warrick Dawes
Greg Summerell
Geoff Beale
Narendra Tuteja
Glen Walker

Technical Report 03/9

This report describes a study of the hydrogeological factors influencing salinity in the Kyeamba catchment, located within the uplands of the Lachlan Fold Belt of south-eastern Australia.

This report is available as an Adobe .pdf file only.

Visit www.catchment.crc.org.au/ publications and search under 'Land-use Impacts on Rivers'

URBAN STORMWATER SOFTWARE

Model for Urban Stormwater Improvement Conceptualisation (MUSIC)

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

MUSIC is available from the Centre Office for $88.00

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

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

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

Data sets collected

We obtained two existing data sets on stormwater quality (Total Suspended Solids –TSS, Total Nitrogen, - TN, and Total Phosphorous – TP) collected in separate systems at: (1) Blackburn catchment in Melbourne (200 ha, mixed land use) and (2) Sandy Creek catchment in Brisbane (220 ha, predominantly residential). The Sandy Creek data was supplied by Brisbane City Council, from their Stormwater Quality Monitoring Program. The Blackburn data consists of N=45 monitored Event Mean Concentrations (EMCs) of TSS, while Sandy CK data has N=90 EMCs of TSS. Climate is very different in these two regions; Brisbane climate being subtropical-tropical and Melbourne being Mediterranean. There may be also a difference in the data acquisition; Melbourne data has been collected purely for research purposes (by dedicated PhD students), while Brisbane data were collected for management and operational purposes.

Methods

The following procedures were performed on the data:

1. The TSS data were Log transformed to approximate a normal distribution. The normality of the distribution was successfully tested using the Kolmogorov-Smirnov distribution test (at $p<0.01$).

2. A re-sampling technique known as bootstrapping (see for example Chernick, 1999) was used. Of N events in the data set, subsamples of n=5, 10, 15...N-1 events were randomly selected (drawn with replacement). This procedure was repeated 1000 times. Each time the procedure was repeated the catchment mean (cEMC) and the catchment standard deviation (cSD) were calculated, resulting in a total of 1000 means and standard deviations for each of n sampled events.

3. The results are plotted as a function of the number of sampled events, n (Figure 4.1 presents the data for Blackburn, while Figure 4.2 the Sandy Ck data). The mean, standard deviation and 95th percentiles were calculated for the $\overline{cEMC}$ and $\overline{cSD}$ for each n (using the 1000 data points calculated as above), and, respectively. We also calculated the 95% confidence level in these estimates.

4. The relative size of the 95th percentile interval was calculated for both cEMC and cSD and for each n, as:

Size of the cEMC95%interval[%]

$$= \frac{cEMC(95^{th}) - cEMC(5^{th})}{\overline{cEMC}} \, 100 \qquad (1)$$

Size of the cSCD95%interval[%]

$$= \frac{cSD(95^{th}) - cSD(5^{th})}{\overline{cSD}} \, 100 \qquad (2)$$

where

$\overline{cEMC}$ - the mean value of 1000 cEMC derived for one n

cEMC (95^{th}) the 95^{th} percentile of cEMC derived for one n

cEMC (5^{th}) the 5^{th} percentile of cEMC derived for one n

$\overline{cSD}$ - the mean standard deviation of 1000 cSD derived for one n

cSD (95^{th}) the 95^{th} percentile of cSD derived for one n

cSD (95^{th}) the 95^{th} percentile of cSD derived for one n

Figure 4.3. shows how the interval size changes with the number of sampled events, n.

Results

Confidence in $\overline{cEMC}$ and $\overline{cSD}$ of TSS was great since we had 1000 points determined for each n (Figures 4.1 & 4.2). In other words their estimates are insensitive to n due to the large number of replicates. Therefore $\overline{cEMC}$ = 139 and 171 mg/l are a very good estimate of the catchment EMC for Sandy Ck and Blackburn, respectivly. From Figures 4.1 & 4.2 it is also clear that, in 95% of the cases when we sample only 5 events, the estimated cEMC will spread within the 140 % and 110 % range around $\overline{cEMC}$, for Blackburn and Sandy CK, respectively. This spread decreases with the number of sampled events, and when n=50, it is down to 42 and 30 %, for Sandy CK and Blackburn respectively. Standard deviation around cEMC is spread slightly less, as shown in Figure 4.3.

Implications for monitoring activities

Examining Figure 4.3, it is apparent that confidence in our estimate of the catchment event mean concentration ($\overline{cEMC}$) increases rapidly as we go from 5 to 20 samples. In other words, monitoring programs which take only 5 or 10 samples cannot provide anything more than a broad indication of the likely event mean concentration. Conversely as our sample size increases past 50 events, the reliability increases only slightly, despite significantly greater expenditure on sample collection and analysis.

We can compare the observed uncertainty with the underlying errors associated with sampling and measurement methods. Recent research has reported these to be at least 30% for TSS (Bertrand-Krajewski & Bradin, 2002; Orr, 2002). Therefore, we can conclude that collection of 50 events is sufficient to give us a reliable estimate of the catchment event mean concentration, and its variability.

Agencies undertaking stormwater quality monitoring should preferably undertake a similar pilot study to determine the required sample size, before investing in a monitoring program.

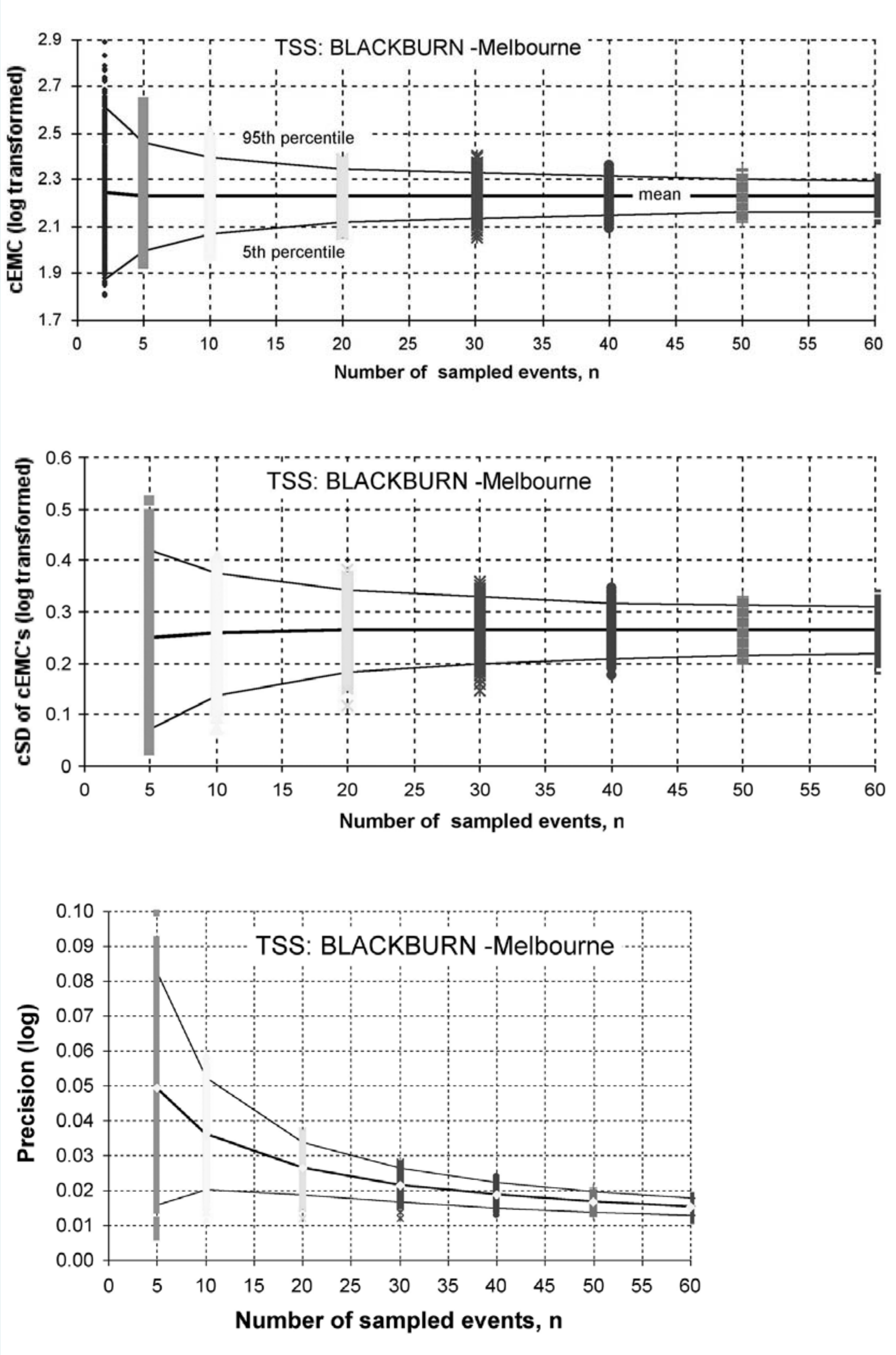

Figure 4.1: Blackburn catchment in Melbourne -Catchment EMC (cEMC) and its standard deviation (cSD) versus number of sampled events, n

MUSIC TRAINING - REGISTER NOW

As part of the Catchment Modelling School planned for 9-20 February 2004, a two day basic and a one day advanced MUSIC training workshop is being offered to MUSIC users.

The Catchment Modelling School will be held at The University of Melbourne and participants can select from a range of over 40 different workshops. For more information about the Catchment Modelling School or to register to attend either of the MUSIC workshops, please visit www.toolkit.net.au/school

NOTE: There are limited places at these workshops, so be sure to register soon to avoid disappointment.

www.toolkit.net.au/school

NEW TECHNICAL REPORT

Predicting the Effects of Large Scale Afforestation on Annual Flow Regime and Water Allocation: An Example for the Goulburn Broken Catchments.

by

Lu Zhang
Trevor Dowling
Mark Hocking
Jim Morris
Geoff Adams
Klaus Hickel
Alice Best
Rob Vertessy

Technical Report 03/5

This report bridges part of the gap between the science of catchment water balances and the management of catchments.The language has moved from "annual average yield " to "water security". Afforestation and water remains a contentious issue. This report sets out an important case study to underpin future decision-making.

Printed and 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 available as an Adobe .pdf file only.

Visit www.catchment.crc.org.au/ publications and search under 'Land-use Impacts on Rivers'

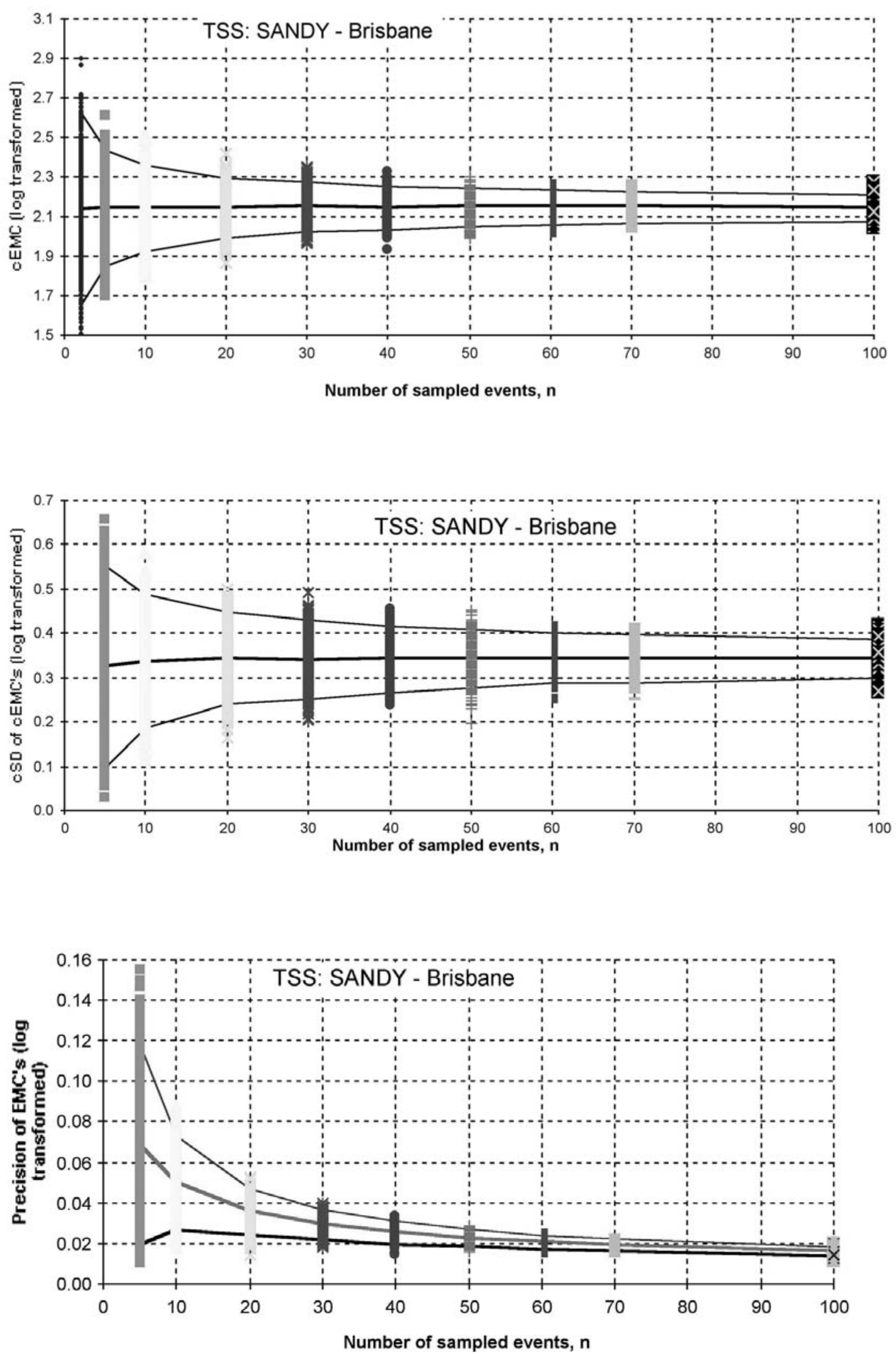

Figure 4.2: Sandy Ck catchment in Brisbane - Catchment EMC (cEMC) and its standard deviation (cSD) versus number of sampled events, n

Acknowledgements
We wish to thank the Victorian EPA's Stormwater Action Program for funding support, Brisbane City Council for access to stormwater quality data, and Melbourne Water for supporting Matt Francey.

References
Bertrand-Krajewski, J.-L., & Bradin, J. P. (2002). *Uncertainties and representativity of measurements in stormwater storage tanks.* Paper presented at the 9th International Conference on Urban Drainage, Portland, Oregon, USA.

Chernick, M. R. (1999). *Bootstrap Methods: A Practitioner's Guide.* New York: Wiley.

Fletcher, T. D., Wong, T. H. F., Duncan, H. P., Coleman, J. R., & Jenkins, G. A. (2001, August 24-27th, 2001). *Managing the impacts of urbanisation on receiving waters: a decision-making framework.* Paper presented at the Third Australian Stream Management Conference: The Value of Healthy Streams, Brisbane.

Orr, D. (2002). *Pollution release from urban asphalt surfaces.* Unpublished PhD, Aberdeen University, Aberdeen, UK.

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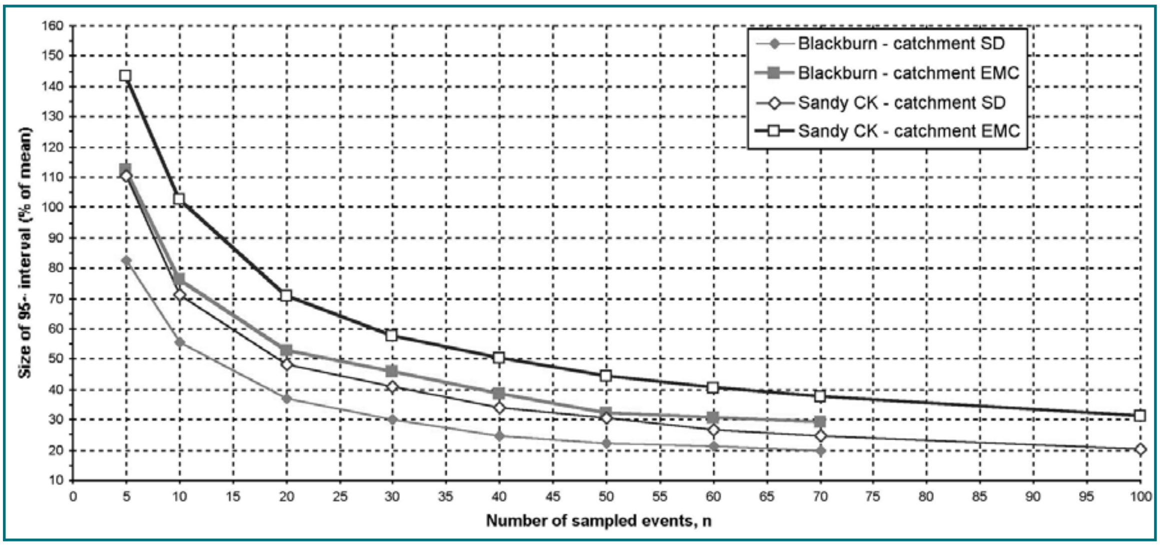

Figure 4.3: size of the 95th percentile interval calculated as given in equations 1 and 2.

WEATHER RADAR CONFERENCE

Sixth International Symposium on Hydrological Applications of Weather Radar

2-4 February 2004
Melbourne, Australia

The major theme of this conference is 'The successful implementation of radar technology for hydrological and quantitative rainfall applications'.

For more information on the symposium, please visit www.bom.gov.au/announcements/conferences/hawr2004 or email hawr2004@bom.gov.au

The conference is supported by the Commonwealth Bureau of Meteorology, the CRC for Catchment Hydrology and the Australia Meteorological and Oceanographical Society

NEW SOFTWARE - CHUTE

www.toolkit.net.au/chute

CHUTE carries out the hydraulic design of rock chutes for stabilising channel beds and is designed for use by professional engineers and managers involved in stream rehabilitation and restoration.

CHUTE is the first of many products that will be available to the land and water industry via the Catchment Modelling Toolkit website at www.toolkit.net.au

The CHUTE software can be downloaded from the Toolkit Members area now at www.toolkit.net.au/members.

For further information including copies of the Rock Chute Design Guidelines, please visit www.toolkit.net.au/chute

PROGRAM 5

CLIMATE VARIABILITY

Program Leader FRANCIS CHIEW

Report by Andrew Western

Soil moisture sampling in the Murrumbidgee Basin

Numerical Weather Prediction and soil moisture

As part of Project 5.05 (5A): Hydrologic modelling for weather forcasting, the CRC for Catchment Hydrology is involved in work to improve the landsurface modelling in the Bureau of Meteorology's Numerical Weather Prediction (NWP) systems. A key aim of this work is improving the representation of the role of soil water availability in controlling the partitioning of available energy into evapotranspiration and sensible heat fluxes. In practice, this involves two interrelated components, initialising the soil moisture in the model for the forecast run (of up to seven days), and simulating the interactions between atmospheric forcing, the soil, the vegetation and the soil water storage adequately.

To provide data support for this work we have been running a series of monitoring stations in the Murrumbidgee catchment for the last two years. These stations are supplemented by spatial sampling of soil moisture. Here we outline the motivation behind the spatial sampling and some results, and report on progress to the public release of the data via the www. We also provide a note on the augmentation of the monitoring in the Murrumbidgee for some new ARC funded projects running out of The University of Melbourne.

Murrumbidgee soil moisture monitoring network

The Murrumbidgee Soil Moisture Monitoring Network extends across the whole basin and consists of eighteen stations (Figure 5.1). Working over such a large area leads to some major scale challenges in designing a practical monitoring protocol. To illustrate this in the extreme, consider that each soil moisture sensor directly represents a spatial area of about 10^{-2} m^2 while the basin is about 10^{11} m^2. Given the number of sensors we have, the proportion of the basin we are directly monitoring is very small - about 10^{-12}. Of course this is an exaggeration because there is some spatial dependence in the soil moisture pattern which means that the stations are representative of a somewhat larger area. Nevertheless, it is clear that an understanding of how the data from point measurements can be interpreted in a landscape context is critical to their use.

To provide a wider landscape context to the monitoring network we have designed two features. Firstly we have chosen to monitor two gauged catchments in more detail. These are the Kyeamba Creek at Book Book and Adelong Creek at Adelong. Both are about 150km², which corresponds to the grid size in the highest spatial resolution continental scale NWP model used by the Bureau. Both cases allow us to compare the model to both the grid scale runoff and to the soil moisture dynamics at five points in each catchment.

The second approach to getting better spatial coverage is to use the University of Melbourne's Green Machine to collect spatial snapshot soil moisture measurements in the top 30cm of the soil profile using Time Domain Reflectometry (Figure 5.2). Near single stations, these transects are about 10km long, which means they sample

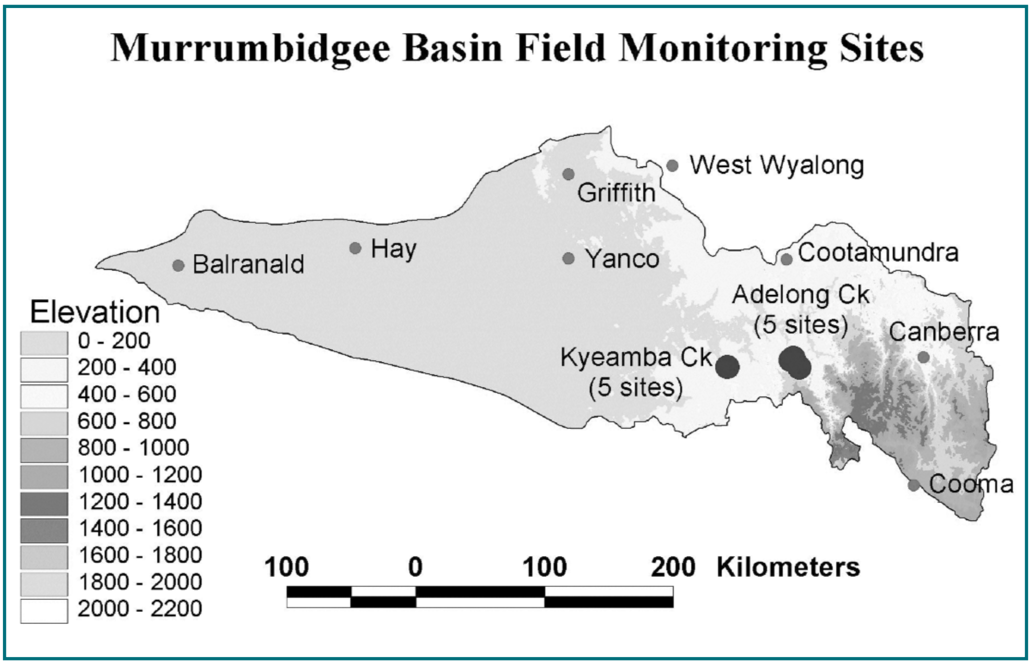

Figure 5.1: The Murrumbidgee Soil Moisture Monitoring Network.

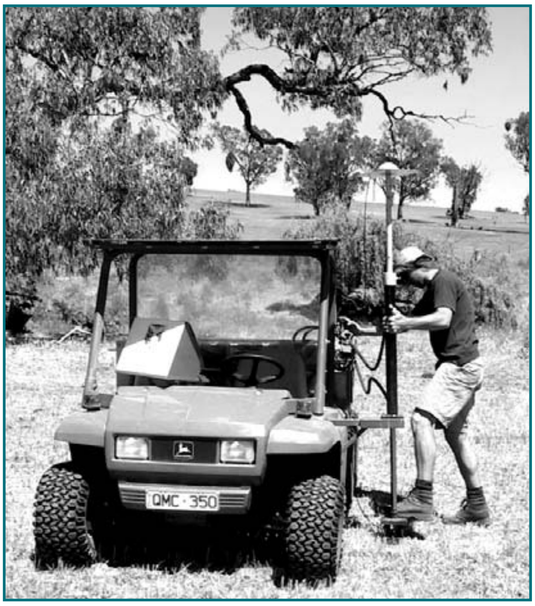

Figure 5.2: The Green Machine in Kyeamba Creek. Photo Rodger Young.

the soil moisture variability in roughly one pixel of the NWP model. In Kyeamba Creek a mixture of transects and patches on different landscape units were sampled. These measurements give us a feeling for how representative our point monitoring locations are. The work has been progressing over the last twelve months.

Results of spatial sampling

Figure 5.3 shows two transects collected at Balranald in three paddocks (nice big paddocks out there – not too many fences to get in the way!). The first was collected in October 2002 during the drought. Only 19 mm of rain had fallen in the past 90 days and 3mm in the last 30 days. The second was collected at the start of November in a much wetter season and two days after about 20mm of rain. There was a difference in the vegetation between sections of the transect and between 2002 and 2003 (Figures 5.3). Clearly it is wetter in 2003 as would be expected but the spatial pattern is also markedly different and bears the mark of the vegetation pattern. In 2002 the whole transect was either unvegetated or sparsely vegetated, whereas in 2003 the central section of the transect had a healthy 40cm high wheat crop that is associated with lower soil moisture conditions.

Figure 5.4 shows a relationship between the wilting point as determined from the 15 bar moisture content (supplied by Neil McKenzie) for the mapped soil units and the soil moisture in November 2002. This demonstrates a relationship between the wilting point and the measured patch average 0-30cm soil moisture, as would be expected given the dry antecedent conditions (only 60mm of rain in the previous 3 months and 4mm in the previous month).

Figure 5.5 presents an overview of the transect sampling results to date. The interquartile range calculated from the transect data is shown along with the measurements made at the monitoring station (four monitoring stations in Kyeamba Creek). The results to date demonstrate that the

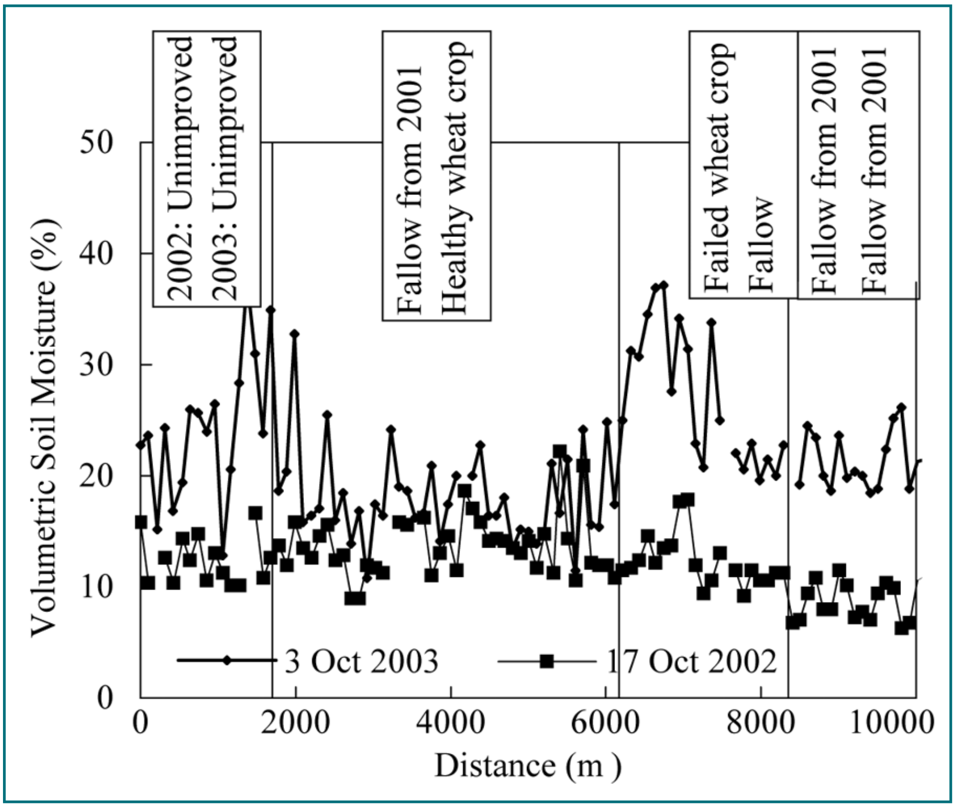

Figure 5.3: Transects of soil moisture from the Balranald area during 2002 and 2003.

CATCHMENT MODELLING SCHOOL 9-20 February 2004 REGISTER NOW

The Catchment Modelling School comprises an impressive range of modelling software workshops presented over a two week period. Professionals in the natural resource management sector can choose specific workshops to improve their hydrologic and related modelling skills.

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Cost

The workshops fees vary between $330 and $440 per day per participant with discounted rates for employees of CRC Parties, Associates, Research and Industry Affiliates and full time postgraduate students.

Register

To register for Workshops, go to www.toolkit.net.au/school and click the 'Register' button. If you have already expressed interest in the School, you will have received an email inviting you to register your Workshops and a link to a personalised registration form.

Registrations for the School close Friday 19 December 2003.

NEW TECHNICAL REPORT

Enhancement of the Water Market Reform Process: A Socioeconomic Analysis of Guidelines and Procedures for Trading in Mature Water Markets.

by
John Tisdell

Technical Report 03/10

This report summarises the main findings of a broad survey of the literature and current government policy on water reform, an extensive survey of irrigator and community attitudes to water reform across the three rural focus catchments of the CRC for Catchment Hydrology and the development and implementation of experimental methods to water management; its auctioning and self governance.

Printed and 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

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soil moisture stations are broadly representative of the neighbouring landscapes. These examples also demonstrate that there are spatial differences in soil moisture that need to be understood so that the point monitoring sites can be better interpreted, showing the value of spatial snapshot sampling.

Public release of data

In addition to the spatial sampling work, a variety of other activity has been going on in the Murrumbidgee including work to finalise the calibration protocols and field calibration sampling for the moisture sensors. Completion of this work will enable the data to be publicly released in early 2003.

New projects

There is also a new project with significant field commitments in the Murrumbidgee getting underway at the University of Melbourne. It is being run by Jeff Walker and Rodger Grayson. This is an ARC project in collaboration with NASA Goddard Space Flight Centre. This project is aiming to test terrestrial soil water store estimates from the GRACE mission and to develop data assimilation methods to make use of these data and those from new satellite instruments such as AMSR in land surface models. As part of this project the soil moisture network is being augmented with additional stations and measurements (gravity, water table depth, deep soil moisture) near Kyeamba Creek and Yanco/Coleambally. Such approaches could provide alternative soil moisture initialisation methods for NWP and seasonal forecasting models.

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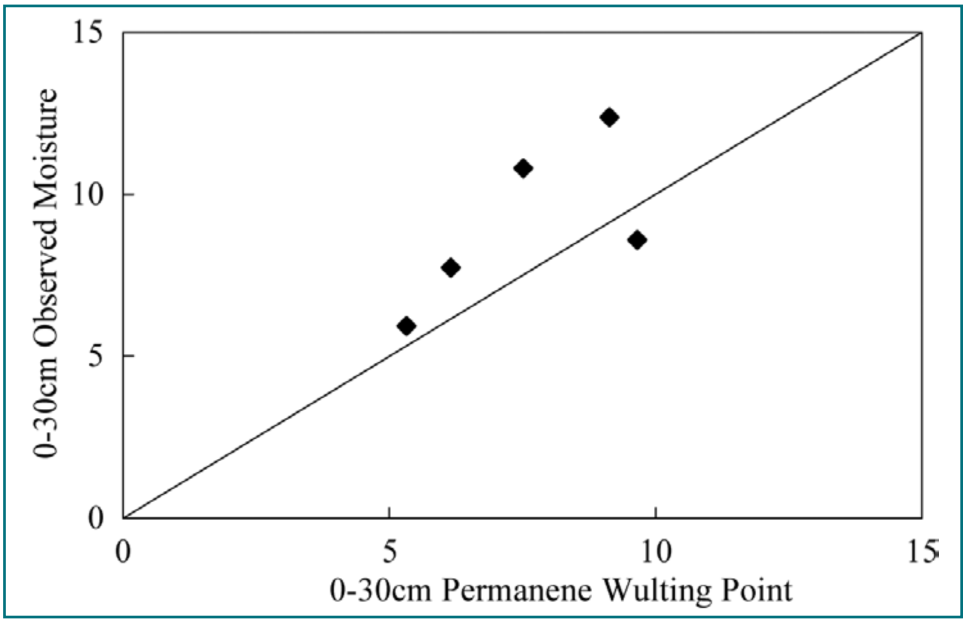

Figure 5.4: relationship between wilting point and patch average soil moisture in Kyeamba Creek November 2002.

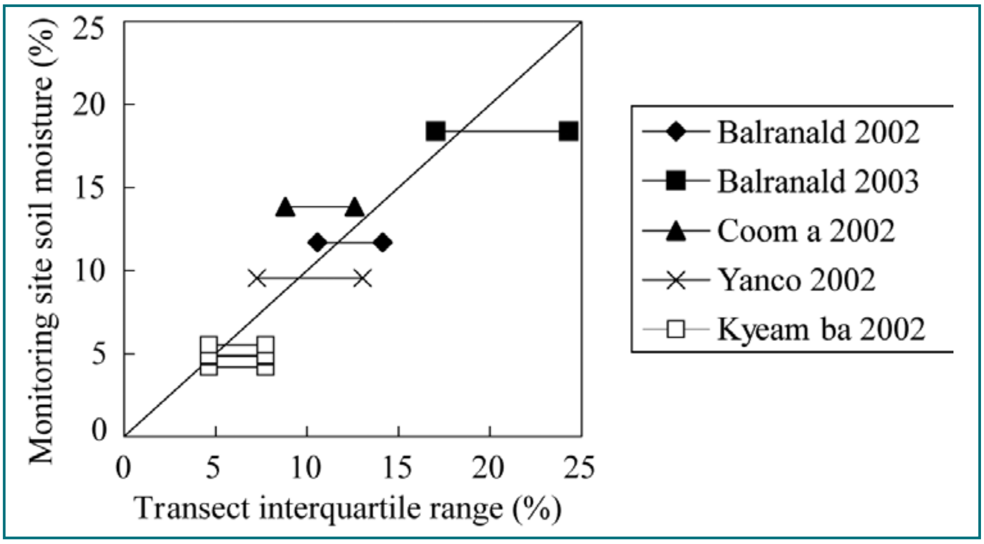

Figure 5.5: A comparison of the transect soil moisture measurements with those at the soil moisture monitoring stations.

PROGRAM 6

RIVER RESTORATION

Program Leader
MIKE STEWARDSON

Report by Dan Borg and Ian Rutherfurd

The Granite Creeks habitat experiment

Many readers will be aware that, with Sam Lake's group in the CRC for Freshwater Ecology, we have been working on a stream rehabilitation experiment on the Granite Creeks – tributaries of the Goulburn River.

The background to the experiment is:

1. In common with 30,000 km of streams in eastern Australia, the Granite Creeks have filled with sand over the last 150 years.
2. We may know that these streams are in poor condition, but how can we best improve that condition?
3. There is a good relationship between the diversity and number of bugs and fish, and the amount of large woody debris (LWD) in these sand bed streams.
4. Thus, as a well designed experiment, we are seeing how adding timber to streams changes the physical and biological condition of the streams. For the physical component of the work, we are seeing how holes form in the sand below the structures during the full range of natural flows.

With the help of the Goulburn Broken Catchment Management Authority, we placed over 40 red gum log sleepers in two streams. The logs spanned the full width, and were placed just above the bed, perpendicular to the flow. Two treatments were applied: a single log in a one hundred metre section, or four logs, eight metres apart. Ecological and geomorphic response at treatment sites is compared to responses in control reaches with no logs.

We have now measured flow depth and bed elevation at all sites over about three years. Fish and invertebrate surveys were also undertaken by the CRC for Freshwater Ecology.

Results

Before the LWD structures were placed, there was no significant difference between flow depth at treatment (one lumped structure and four structural treatments) and control sites. The structures produced a significant increase in flow depth at the treatment sites (Refer to Figure 6.1). Even when there was aggradation of the stream bed at control sites, there was still streambed scour and a local deepening around the LWD structures following installation.

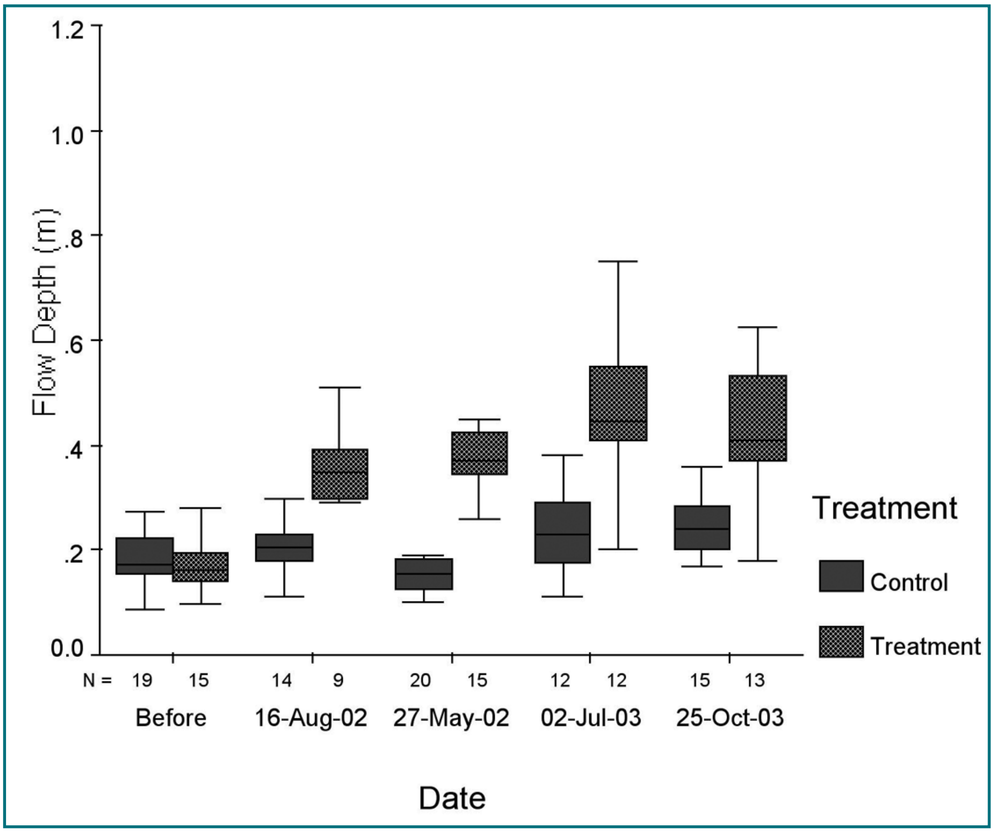

Figure 6.1: Flow depths at Control and Large Woody Debris Treatment sites in Creightons Creek. 1_ Structure and 4_ Structure treatments have been lumped. Prior to installation of the structures, there is no significant difference between flow depths at treatment and control sites. Following installation, there was a significant increase in flow depths at each of the treatment sites.

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Registrations for the School close Friday 19 December 2003.

As can be the case with this sort of field experiment, the monitoring took place in one of the longest droughts to strike NE Victoria. Despite this hydrological extreme, CRC for Freshwater Ecology found significant increases in abundance of one native fish species (Mountain Galaxias, Galaxias olidus) associated with the four structural treatments before the low flow spell, and a buffering of the declines of two other native fish species relative to the declines observed at sites not subject to habitat manipulations.

We expected a reasonably simple pattern of scour around these simple structures. However, there was great variation in scour depth for the same simple LWD treatment, for the same range of flows. The persistence of LWD-induced scour pools can be very dynamic and entirely dependent on flow regime. Some structures were completely buried by sand; and later re-scoured. It is not only the magnitude of a scour-inducing flow event that governs the persistence of a given scour pool, but also the duration and frequency of flow events.

Pressure-based monitoring

To address this dynamic, highly variable nature of scour, we developed a novel method of monitoring stream bed elevation in the Granite Creeks system. The method is pressure-based, and uses geotechnical instrumentation to monitor the changes in pressure of sediment in real-time (independent of the changes in water pressure associated with flow events). This change in pressure is linearly related to changes in sediment depth. The method has been developed by the CRC for Catchment Hydrology, and overcomes many of the limitations of traditional real-time streambed elevation monitoring techniques.

The limited real-time data set of scour around LWD structures logged so far has revealed significant within-event variation in scour depth, and has even captured the burial of the sleeper structure monitored (Figure 6.2).

Implications for Management

The Granite Creeks trial has revealed that geomorphic diversity can be restored using large woody debris, and this can have positive effects on fish abundance. Even in this simplest case of LWD, there has been great variation in the geomorphic response, including complete burial of the structure. The new pressure-based bed elevation monitoring technique is allowing us to develop stochastic rather than 'single event' models of bed scour.

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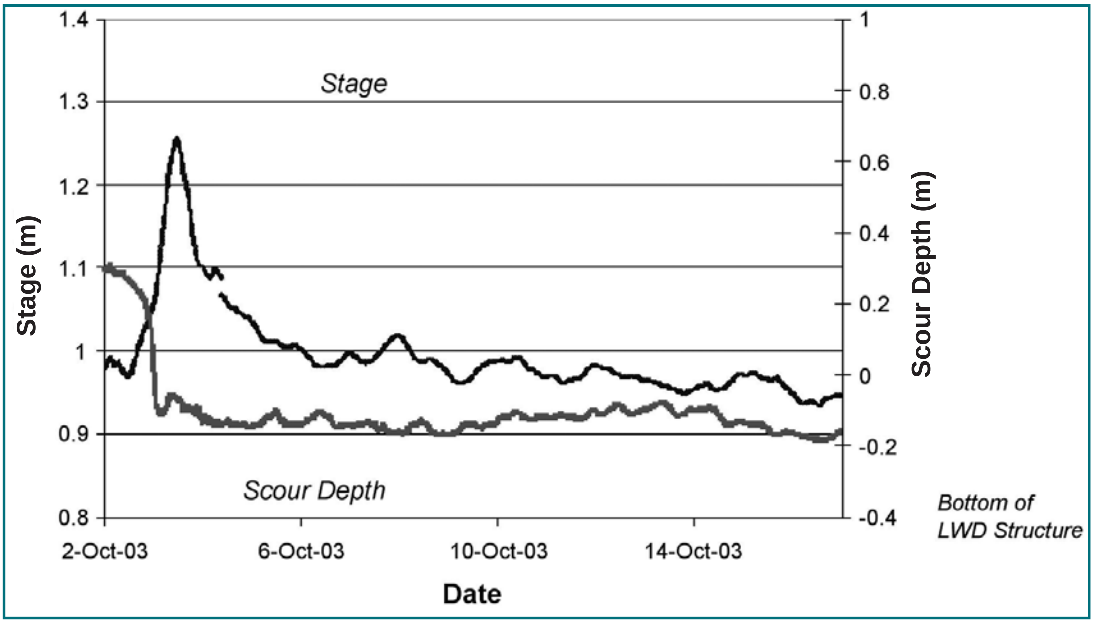

Figure 6.2 Real time, pressure-based monitoring of streambed elevation. Time series of stage and scour depth (depth below the bottom of the sleeper structure). Negative scour depths indicate burial of the structure with sand.

COMMUNICATION AND ADOPTION PROGRAM

Program Leader DAVID PERRY

The Flow on Effect – November 2003

catchment modelling SCHOOL04 www.toolkit.net.au

At a glance – a summary of this article

***Catchword* readers who would like to attend specific workshops offered at the Catchment Modelling School during 9-20 February 2004 in Melbourne are now able to register at the School web site www.toolkit.net.au/school**

Registrations close on Friday 19 December 2003 and places will fill quickly, particularly in the most popular workshops. A brochure with School details is included with this edition of *Catchword*.

The Catchment Modelling School

Regular *Catchword* readers will be aware that the CRC for Catchment Hydrology is holding its first Catchment Modelling School during 9-20 February 2004 at The University of Melbourne. The School with its series of practical workshops is part of the CRC's commitment to building and enhancing the hydrologic and related modelling skills within Australia's land and water management sector.

During the School the CRC is offering a wide range of modelling software-based workshops and general seminars for participants during the two week period. The length of workshops will vary from half a day to three days depending on the content and objectives.

A call for expressions of interest in the proposed workshops during 22 October – 7 November 2003 resulted in over 220 responses. Based on preferences given, the proposed workshop program has been designed to minimise clashes between popular courses.

Details of courses, times and dates are available at www.toolkit.net.au/school

To register for workshops

Catchword readers can register for School workshops between 17 November 2003 and 19 December 2003. If you would like to register then please visit www.toolkit.net.au/school and fill in your contact details. You will then able to select from the range of workshops being offered. Based on your choice of workshops you will be guided through a step by step process that invites you to create a registration form containing your contact details and workshop selections. The form can then be printed, your payment details entered and faxed to the Centre Office. An email will be sent to you to confirm your registration.

Workshop fees

The workshop fees vary between $330 and $440 per day - for example the fee for a two day workshop will be between $660 and $880. Most workshops include a copy of the relevant software and supporting documentation so that participants can apply their new skills back in the workplace. The fee (per day) also includes lunch and morning and afternoon teas.

CRC concession rate

A concession rate applies to employees of CRC Parties, Associates, Research and Industry Affiliates and full time postgraduate students. Staff from these organisations and all full time postgraduate students are entitled to a discount of $110 per day from the cost of each workshop. This option is included in the registration process and in some cases proof of eligibility may be required. The CRC concession rate acknowledges the role and contribution that these participating organisations are making to the success of the CRC.

Other details

Accommodation, breakfast and evening meals are not included in workshop fees. However, meals with colleagues can be arranged in the nearby Lygon Street precinct where a wide range of cuisines and atmosphere can be found. Participants from outside Melbourne can also find a range of accommodation suggestions and contact details at www.toolkit.net.au/school

Complementary series of short industry seminars

To complement the user-focussed modelling workshops, the CRC will also present a series of focused one-hour briefings on key related issues involved in catchment modelling. These short industry seminars will assist managers and other senior staff whose range of responsibilities include catchment management and modelling. Focussing on broader industry and

NEW TECHNICAL REPORT

The Impact of Rainfall Seasonality on Mean Annual Water Balance in Catchments with Different Land Cover

by

Klaus Hickel
Lu Zhang

Technical Report 03/11

Our understanding of catchment hydrology is approaching the point where we can confidently predict the partitioning of rainfall and how it changes when we change the land use. This report describes some of the research that supports this important development. By enabling the consideration of seasonality, it enables more confidence in our prediction of how catchment hydrology changes when land use changes.

Printed and 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 available as an Adobe .pdf file only.

Visit www.catchment.crc.org.au/publications

management issues, principles and practices, the short seminars will be scheduled during early morning and late afternoon sessions. There will be no charge for participating in these industry short seminars.

A timetable of these short industry seminars will be available at the School web page during January 2004.

Further information
For further information please visit the Catchment Modelling School web site at www.toolkit.net.au/school or contact the Centre Office on 03 9905 2704 or email crcch@eng.monash.edu.au I suggest registering early to ensure a place. There is no doubt that many of these workshops will fill quickly.

See you in February in Melbourne.

David Perry
Communication and Adoption Program
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Email: david.perry@eng.monash.edu.au

POSTGRADUATES AND THEIR PROJECTS

Asif Mohammed Zaman

After completing my Masters in Environmental Engineering at Imperial College (London) in 1999, I was playing around with the idea of pursuing a PhD. I was not sure in what area or field of water resources management to look into. I felt that a few years in industry would help. I spent a few years working in the UK and Bangladesh for a couple of engineering consultancies.

My experiences lead me to set a goal of becoming a consultant/expert in water resources policy and planning. I am particularly interested in the interaction between the hydrological and bio-physical dimension of water resources and the relevant socio-economic issues. So, when I heard about the CRC for Catchment Hydrology program for integrating water models and economic models – I was salivating!!!

My research project aims to identify the potential drivers for temporary water trading in the Goulburn-Broken Catchment in North Victoria. An objective is to incorporate these drivers into an integrated economic and water allocation model. This integrated model will then help traders, resource managers, policy makers, and water supply authorities estimate the likely directions of water movements throughout the season.

Why bother? – I hear you thinking. Although the volumes traded over a year amount to about 15-20% of total irrigation water delivery, in certain months of the season, this percentage can be significantly higher. This has implications on how the system will operate and is managed and the total benefit obtained from the available irrigation water. However, existing water allocation models do not incorporate water trading, which is a gap this CRC program is trying to fill.

So far, 14 months into my PhD, I am pleased to say that I still love what I am doing. The first 10 months or so were hard because I had to brush up on my economic theory and principles, and it will always be a learning process. Also, covering the wide range of journals that deal with water trading/markets was, and still is, a major challenge.

Anyway, now I have collected some trading data from Goulburn-Murray Water and have been trying out various multi-variate regression models to see what explains the variation in water supply and demand along with traded volumes and market prices in the temporary water market. Interestingly, it is clear that water price is not the only factor, especially for suppliers to the market during the last irrigation season. I am trying to improve the R^2 value by including other variables such as number of weeks into the irrigation season, climate data, commodity prices, etc. The real fun will start when I try to predict what will happen for the rest of the season!!! I am not expecting my R^2 for the supply and demand functions to be 1, as there are always speculators in the market and I also need to leave some work for others to do.

One of the other important drivers of water trading identified so far, apart from the water price, is water availability. This information, along with some relevant climate information, will be provided by the water allocation model. Thus, the next major step in my research project will be to get REALM (the water allocation model) and the water trading model speaking to each other. The idea is that each month, the trading model will take the initial biophysical water demand from REALM, as an exogenous variable, and then adjust it for relevant irrigation areas due to water trading, depending on the values of other exogenous variables (trade drivers). These new demands will then be used to re-run REALM. The resulting water availability and demand values would then be used by the trading model in the next month.

Anyway, if you are still reading this article to this point – good on ya!! I look forward to receiving some feedback and fresh ideas that you may have.

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OTHER OUTLETS FOR CRC PUBLICATIONS

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

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

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

CRC PROFILE

Our CRC Profile for November is:

Jake MacMullin

As a recent recruit to the CRC, I still find myself wondering how I ended up in Canberra, working with a group of scientists and software engineers who spend all their time thinking about water. To be entirely honest, I have spent more time thinking about water in the past 3 months than I have over the last 24 years.

I was born 24 years ago in the South Australian town of Strathalbyn and spent much of my childhood travelling with my family. After spending a few years in Mt Gambier, Canada, Mt. Gambier again and the United States, we finally moved to Adelaide when I was about 10.

As I progressed through school, I showed early signs of what has now developed into my passions: a strange mix of creativity and a need for technical challenges. In primary school I couldn't get enough maths/science – I spent lunchtimes writing computer games with friends in BASIC on BBC microcomputers, and I was even a member of CSIRO's 'Double-Helix Club'! However, in high school – my alter ego emerged and I forgot about maths and science and become obsessed with Art and Drama. I focussed on Art and Drama in my final years of school – hoping to win a position at university studying filmmaking.

When I didn't win one of the few positions in a film and television degree – I decided to spend a year working and apply again the following year. So I landed myself a job as a pre-press graphic artist (a perfect combination of creativity and technical challenges). After a year of spending most days sitting in front of a computer the pendulum started to swing back the other way and I found myself more interested in the workings of the computer than the creative process of graphic design.

When it came time to apply for university again I realised that I hadn't thought about filmmaking for months, and I was fascinated by the prospect of studying computer science. I wasn't entirely convinced though (what if computer science was all maths and geeky stuff? What if I didn't like it?). So I hedged my bets, and enrolled in a double-degree – Computer Science and Arts. Three and a half years later, I was convinced – computer programming could provide both a creative outlet and plenty of technical challenges. Although it became clear that I enjoyed the technical and logical nature of computer programming, and found it more and more difficult to enjoy the subtleties of post-modernism and Foucault's theories of discipline and control, there was a side of me that still sought a creative outlet. During university, I explored both sides of my personality by getting involved in web development. Initially, this consisted of designing web sites (focusing on the creative side) – but as I learnt more about computer programming, I become more interested in the mechanisms behind the scenes – the databases and programming languages that drive dynamic websites.

After graduating from university, this interest in web development (and perhaps some lingering interest in Foucault) led me to a job as a web developer with the South Australian Department for Correctional Services. As part of a small web development team within the department, I was involved in developing a content management system for the Department's Intranet. Although I enjoyed my work in the Department for Correctional Services, I found it difficult to become 'engaged' with the 'business' of the department, so as this project was winding to a close, I kept an eye out for a similar role in an organisation where I felt I'd be able to play more of a role in the 'business' of the organisation.

When my fiancée applied for a job in Canberra, and I saw a position advertised with CSIRO the next day – I thought it was worth finding out more about it. When I found out that the position was to replace a web developer that I knew through our shared interest in the same kind of development tools, it seemed like too good an opportunity to let go.

I guess that answers my own question. That's how I ended up in Canberra working with a group of people who are interested in Hydrology. Although I have only been here for a few months, I can tell that this position will not only allow me to continue developing my passion for web development and programming, but I am already becoming 'engaged' with the 'business' of the organisation. This hydrology stuff is pretty interesting.

Jake MacMullin
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WHERE ARE THEY NOW?

Report by Wijedasa Hewa Alankarage

Well, I left the University of Melbourne where I had been for almost four years. After completion of my draft PhD thesis, I joined Southern Rural Water as a project engineer. I am not far away from Melbourne and stationed at the Werribee office of Southern Rural Water.

My PhD thesis title was ' Implications of water transfers on environmental flows in northern Victoria'. In my research, I was trying to quantify impacts of possible permanent and temporary water transfers on river flows. In this research, drivers of water transfers were studied and outcomes of the study were used to model impacts of water transfer scenarios on streamflows and the environmental flow component of those streamflows in northern Victorian rivers. The Broken, Goulburn, Campaspe and Loddon rivers were analysed to identify impacts of water transfers. I combined a model developed by me with the Goulburn Simulation Model (a calibrated REALM model for the Goulburn-Broken system) for the analysis.

The research showed that overall streamflows are sensitive to changes in water use arising from water transfers and related options. This study provides important insights that will help sustainable management of water transfers into the future.

I have yet to submit the final thesis. If everything goes well, I will finish this step within next two months.

My research at The University of Melbourne has provided an opportunity for me to learn more about Victorian agriculture. Knowledge from this research, and my previous experience as an irrigation engineer, has been valuable in assisting me fulfil my present duties in Southern Rural Water. It is interesting to note that some of my tasks directly relate to my previous research activities. One such example has been work in reviewing the Thomson-Macalister Simulation Model (calibrated REALM model for the Thomson-Maclister system).

I am thankful to my supervisors Hector Malano and Tom McMahon for their support and guidance during my research. There are many others particularly in the University of Melbourne, Goulburn-Murray Water and the Department of Sustainability and Environment who helped and spent their time with me. Thanks to all of them.

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CATCHMENT HYDROLOGY

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OUR MISSION

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

OUR RESEARCH

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

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

CRC AUSTRALIA

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

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

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, Korea
University of New South Wales

Industry Affiliates:
Earth Tech
Sinclair Knight Merz
WBM