NEWSLETTER OF THE COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CATCHWORD

NO 104 APRIL 2002

A NOTE FROM THE DIRECTOR

Professor Russell Mein

Inside...

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

CONTINUING THE TRADITION

One of my enduring memories is of the 1965 Hydrology Symposium. This was the first technical symposium I attended - I was a Masters student at the University of Melbourne at the time - and my first exposure to the leaders of the emerging field of engineering hydrology. There were just ten papers (mailed out three weeks in advance!), and perhaps 50 participants, over a two-day format. There was plenty of time for a detailed presentation, and vigorous debate, of each paper. It was certainly an effective format.

The technical highlight for me, as I've said before, was Walter Boughton's presentation of his first daily rainfall-runoff model. By 1965, computer software had made rapid computation possible. The field of hydrology, with the need to handle large quantities of data, was a prime beneficiary. Walter had put together algorithms to simulate hydrologic processes on small catchments, and was thus a pioneer in the field which has had so much interest and application since. [I should add that Walter is still an active model developer!!]

Melbourne, May 2002

It is a delight for me that the hydrology symposium series has also endured, with an event held every 18 months. It has changed of course, being very much larger now, and covering a far broader field than the engineering hydrology of decades ago. The format has changed somewhat too, with parallel sessions needed to cope with 100 or so paper presentations over three days. By this means, the organisers continue to ensure that adequate time is provided for both presention and discussion.

The 27th Hydrology and Water Resources Symposium is being held this year in Melbourne, over 20-23 May 2002. It was last there in 1982! The 2002 theme is a topical one "The water challenge - balancing the risks", aiming to focus on the competing demands for water and a sustainable allocation. 'Modelling the hydrologic cycle' is still in there as an important sub-theme, alongside 'Sustainable resource management', 'Protecting people, infrastructure and the environment', and "The new tools". The latter will bring out the advances now brought by remote sensing, compatible databases of land and water information, and computing power.

The event will feature four keynote speakers. David Maidment (Director, Centre for Research in Water Engineering, University of Texas; Editor of the McGraw-Hill 'Handbook of Hydrology') will lead off on new tools for applying GIS in hydrology. Tom Hatton (CSIRO, Perth) brings new perspectives to the best directions of efforts to manage dryland salinity. Nancy Millis (Emeritus Professor, University of Melbourne, and a 2002 'Legend of Australia' in the Australia Post stamp series) considers the quality implications of water use and re-use in current drives for 'efficiency'. Geoff Pegram (University of Natal, South Africa) will present some surprising results from work on scaling of rainfall and flood data over a range of catchment sizes.

I should also mention Ian Cordery (UNSW), who will be giving this year's Munro Oration. [Professor Crawford Munro is widely regarded as the father of hydrology in Australia, and the instigator of the symposium series. Each year, an eminent speaker is chosen to deliver an address to honour his contributions]. Ian has an outstanding record in Australian Hydrology, particularly in the area of design flood estimation; a couple of chapters in 'Australian Rainfall and Runoff' bear his name. As a former associate of the late Crawford Munro at UNSW, Ian will feel particularly honoured at this recognition of his achievements.

CRC involvement

The CRC has been actively involved with the Hydrology and Water Resources Symposium series. This symposium is particularly successful in bringing researchers and research-users together, so we value the opportunity to participate; mostly, through presented papers and discussions. This year, with the event in Melbourne, the CRC is providing further support, including three members of the CRC on the Organising Committee, in addition to paper presenters.

It's going to be a great symposium. I hope to see you there?

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PROGRAM 1

PREDICTING CATCHMENT BEHAVIOUR

Program Leader
ROB VERTESSY

Report by Rob Argent

Demystifying Toolkit Water Quality Models

Background

Catchment scale prediction of water quality lies at the heart of much of the CRC activity. This month we look at some of the examples of different types of water quality models that are, or could be, developed within the Toolkit, and reiterate the toolkit philosophy on modelling.

Members of the toolkit team are involved in a range of management-focussed water quality modelling activities, and their experience is being used to inform and populate the Toolkit. For example, we have led or had input to catchment based water quality management strategies in Victoria, coarse scale water quality source assessment for Port Phillip Bay, salinity and yield modelling in New South Wales, the South East Queensland Regional Water Quality Management Strategy, and sediment and flow estimation for the Fitzroy Basin, Queensland. The Toolkit is designed to provide modelling to support all of these, and many other activities as well.

Data for catchment modelling

One of the interesting aspects of different scopes and scales of water quality modelling is that, although they use a range of assumptions and levels of detail on process representation, they all use pretty much the same data - continuous flow and occasional water quality - for calibration and testing. Thus the quality of the "real" values against which we compare model outputs does not greatly differ from model to model, and these 'real' values generally have severe limitations, such as high variability arising from highly variable flow combined with often non-linear flow-concentration relationships.

The basic data sets for catchment scale water quality modelling are:

- Rainfall, Evaporation
- Flow
- Land use / cover

On top of these are often added data on:

- Elevation
- Dams and control structures, extractions, diversions, point sources
- Other items, such as road network / density, soil type / geology, stream condition, erosion hazard

Concepts for catchment modelling

In concept, catchment scale water quality modelling can be viewed as shown in Figure 1.1, with runoff being combined with pollutant generation and routed to some point or receiving water where the load or concentration of pollutants is of concern. The range of models and model types that fit with this concept is, however, large, as shown below. These models include:

- static distributed
- semi-static distributed
- dynamic gridded
- dynamic distributed

(Note that the model nomenclature is arbitrary – part of our work over the coming years is to establish a common language for describing models that is more informative than acronyms and primates.)

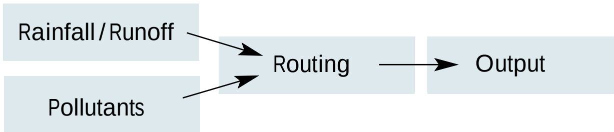

Figure 1.1 Catchment scale water quality modelling

- Static Distributed

Static distributed water quality models can provide information on the relative contribution to total load from different areas on either a total or unit area basis. Such models, represented by *Figure 1.2*, have a total pollutant load based on the summation of loads generated from various land uses. The summed loads are compared with 'true' loads estimated by combining monitored flow and water quality, or established flow-concentration relationships.

For these models, the ratio of the land-use based loads and the 'true' loads gives an indication of the delivery efficiency of the catchment, representing lumped catchment transport and transformation processes. Scenario exploration can be undertaken by changing land uses, delivery ratios or generation rates, to represent a range of management actions. FILTER, the model used for Port Phillip Bay load assessment, is an example of such a model.

Within the Toolkit, ICMS provides a capacity to build such a model by linking sub-catchment objects (containing land use data) to produce a catchment system. For yield analysis (rather than water quality), the MAYA model implementation of the Holmes-Sinclair relationship, built using Tarsier, is an example. These types of models are designed to provide information on long term changes to total pollutant loads (or yield) in response to management activities.

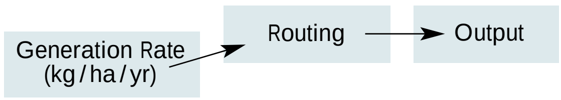

Figure 1.2 Static distributed water quality models

- Semi-Static Distributed

Semi-Static Distributed models can also be represented by *Figure 1.2*. In these kinds of models, sub-catchments are, again, represented in the form of land use mixes. Changes to land use are made during scenario exploration and the impact over time of the catchment load from one static (long term average) value to a new equilibrium value is estimated.

The Terrapene model, being built using Tarsier (see *Catchword*, February 2002) is an example of such as model, showing the time dependent change in yield and salt load of a catchment in response to changes in land cover, primarily forest cover.

- Dynamic Gridded

Dynamic Gridded models (eg *Figure 1.3*) typically have rasterised values of land use/cover, and climate, spatially explicit addition or extraction of flow and pollutants, cell-based rainfall-runoff estimation, and operate dynamically over time using climatic data series and routing from cell to cell. Estimated loads are compared with 'true' loads estimated by combining monitored flow and water quality, or established flow-concentration relationships.

These are typically the kinds of models used in AEAM activities such as that which is ongoing as a joint CRC for Catchment Hydrology/CRC for Coastal Zone project in the Fitzroy River basin. An implementation of such a model from a Western Australian catchment (with separate surface and sub-surface water routing routines) has been built using ICMS, and developments of this approach are ongoing.

These types of models provide a level of spatial and temporal specificity that allows examination of the effects of management actions at particular positions and times in the catchment, so are useful for highlighting low-flow/high-flow or other discrete effects that are not seen in non-dynamic models.

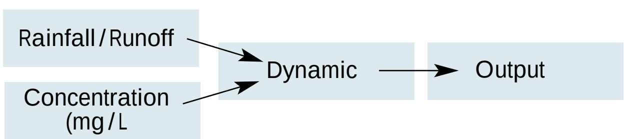

Figure 1.3 Dynamic gridded water quality models

- Dynamic Distributed

Dynamic Distributed models are similar to dynamic gridded models, except that they are built around sensible areal units, such as sub-catchments or hydrologically similar units. Each unit contains a rainfall-runoff model, and flow and pollutants can be dynamically routed. Predictions are influenced by climate and management activities, reflected in diffuse land use-based generation rates, point source discharges and quality, and changes in land use and land cover.

The EMSS for South-East Queensland (see *Catchword*, June 2001), built using Tarsier, is an example of such a model.

Modelling Gaps

Readers may have noted that the small range of models listed above have many gaps – how about a gridded model with dynamic routing between cells?, or perhaps a landuse-based generation rate model with climate-dependent pollutant generation?

Well, that's the whole point of the Toolkit! By providing modelling services based on model components (aka modules) such as runoff generation, pollutant generation, or routing, as well as standard and re-usable components of handling data, analysis, visualisation and reporting, we can start by describing the problem that needs to be addressed and then select which components need to be combined into a model to provide an appropriate solution.

During the next few months we will be planning our 2003-2005 activity so that over the coming three years we will continue to improve the underlying software, the application development environments and the tools delivered by the Toolkit project.

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NEW TECHNICAL REPORT

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

by
Francis Chiew
Philip Scanlon
Rob Vertessy
Fred Watson

Report 02/1

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

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

Copies available through the Centre Office for $27.50.

NEW TECHNICAL REPORT

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

by
Francis Chiew
Philip Scanlon

Report 02/2

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

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

Copies are available through the Centre Office for $27.50

For further information contact the Centre Office on 03 9905 2704

PROGRAM 2
LAND-USE IMPACTS ON RIVERS

Program Leader
PETER HAIRSINE

Report by Gary Caitcheon

Sources to sinks: where does the sediment in South East Queensland come from?

Background

An aim of Project 2.1 ('Sediment movement, physical habitat and water quality in large river systems') is to develop a better understanding of sediment and associated nutrient transport using large-scale, physically based process models supported by sediment tracing techniques. Our first attempt at combining these methods, implemented in South East Queensland, has demonstrated the value of this approach.

The settlement and development of South East Queensland has significantly altered landscapes, and the riverine and estuarine environments. Degradation of habitat and water quality has caused concern in the community, and in all levels of government. A major initiative to better understand and manage these problems is the South East Queensland Regional Water Quality Management Strategy (SEQRWQMS), a staged approach to research and management. The SEQRWQMS aims to develop a water management plan to protect and enhance the riverine and marine environments of South East Queensland. The initial research focus was on Moreton Bay. This work identified sediment and nutrients as playing an important role in the degradation of habitats within the Bay and associated estuaries. As part of the later research strategy that began to focus on the catchments, a two-year study was initiated to determine the origins of the sediment.

The principal objectives of our study were to determine the relative contributions of sediment originating from surface and subsoil erosion, as well as the catchment areas that are contributing most sediment to the lower reaches of the main rivers, and in particular to Moreton Bay. Our study was conducted in two phases, the first included an analysis of existing data, culminating in outputs generated by the SedNet model developed for the National Land and Water Resources Audit. In the second part of the study sediment-tracing techniques were used to test the model predictions.

Model predictions about which erosion processes are important

What we found:

- Gully and stream bank erosion are the dominant forms of erosion
- Cultivated land is an important potential source
- In some coastal catchments, hillslope erosion is likely to be a significant source

The SedNet model is a physically-based process model that uses simplified forms of equations that describe erosion and sediment transport. Data sources for the model include rainfall, stream flow, digital elevation models, and remotely sensed land cover. Measurements of river width and gully erosion were made from aerial photographs. The model generates a mean annual sediment budget downstream through a river network. Sediment generation from hillslope erosion, gully erosion, and stream bank erosion is estimated along the river. Deposition of sediment on floodplains and in reservoirs is simulated and used to calculate the sediment

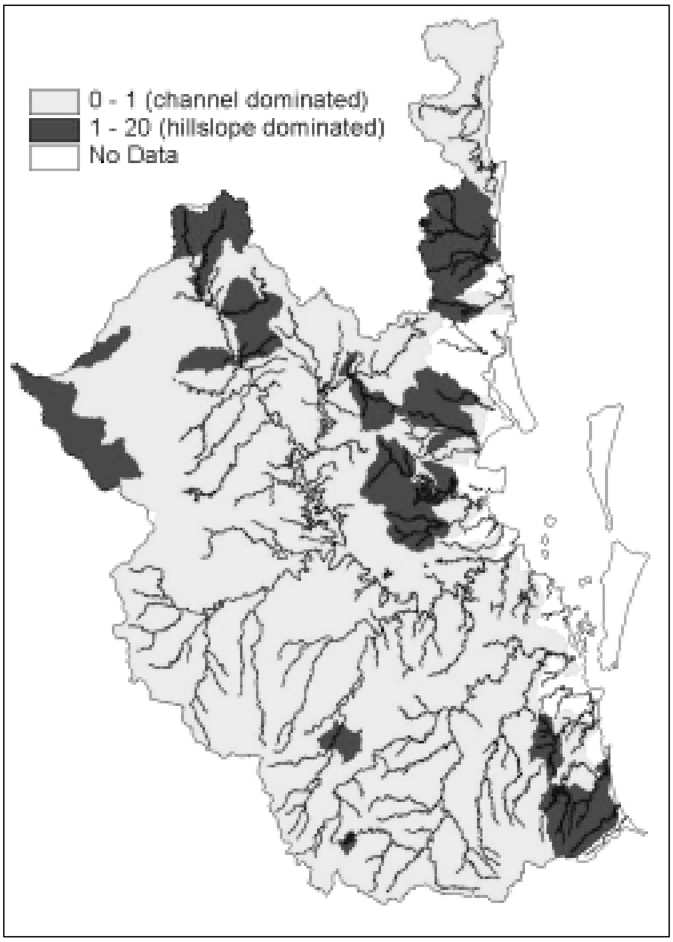

Figure 2.1 SedNet predictions about catchment areas dominated by channel (ratios <1) or hillslope (ratios >1) erosion.

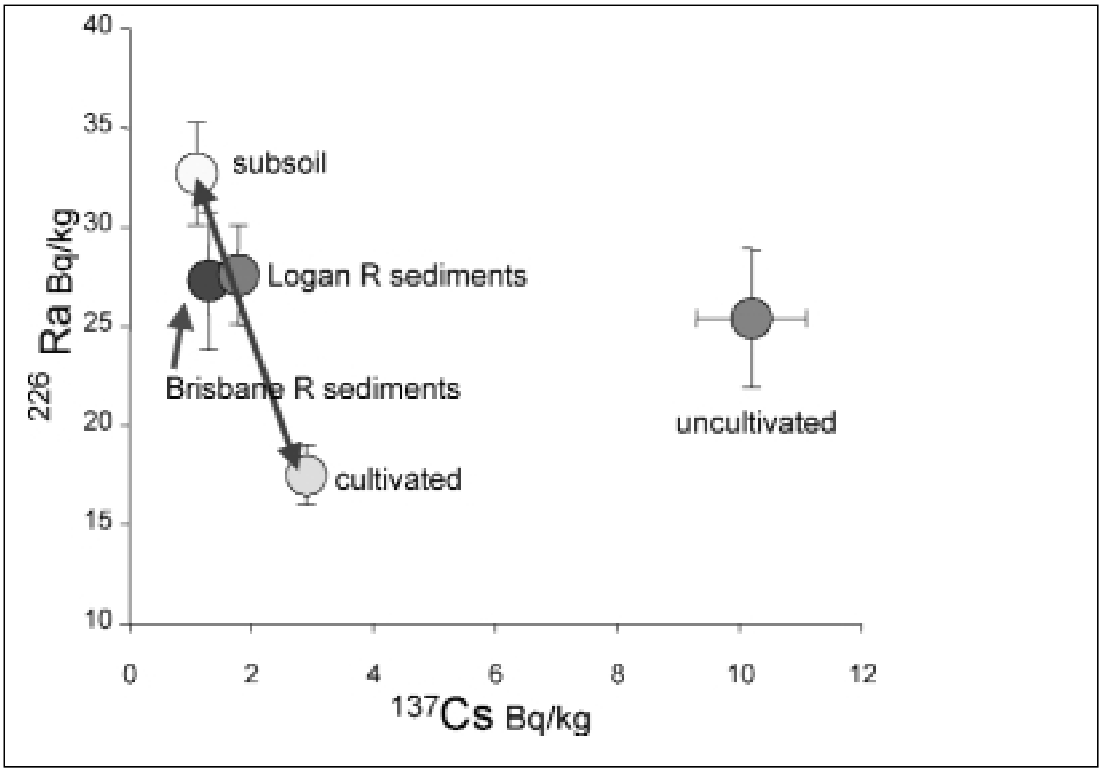

Figure 2.2 Mean ^{226}Ra and ^{137}Cs concentrations showing that most of the sediments delivered to the lower Brisbane and Logan Rivers originate from channel erosion. The other source is cultivated surface soils.

yield that is delivered downstream. Although the model predicts the transport and deposition of bedload, in this study we only used model predictions for suspended sediment because this is the size fraction delivered to coastal estuaries and Moreton Bay. The model does not predict erosion and sediment transport in urban areas.

Figure 2.1 shows the SedNet model predictions for the ratio of hillslope to channel erosion (gullies and stream banks) in South East Queensland. The model clearly predicts that channel erosion is the dominant form of erosion. Hillslope erosion is predicted to be important in some coastal catchments. These regional predictions are indicative of the average, long-term situation. They do not necessarily define the dominant form of erosion at a particular place, which may vary due to local factors such as the current land management and prevailing climatic conditions.

What the erosion process tracers tell us

What we found:

- Gully and stream bank erosion generates about 75% of the sediment delivered to the Brisbane and Logan Rivers
- Erosion from cultivated land produces most of the rest of the sediment in the Logan and lower Brisbane catchments
- Sediment yield from grazing land is generally low, but in the upper Brisbane River catchment it makes a detectable contribution
- In most of the coastal catchments, channel erosion is the dominant sediment source

Sediment tracing methods provide us with an independent means of testing the model predictions. Surface soil samples were collected throughout the region from cultivated and uncultivated lands, and from gully and stream bank subsoils. These source types can be distinguished by measuring concentrations of caesium-137 (^{137}Cs and radium-226 (^{226}Ra). ^{137}Cs is a product of atmospheric nuclear weapons testing that occurred in the 1950-70s. It accumulates in surface soil, and labels sediment eroded from topsoils. ^{226}Ra is a naturally occurring radionuclide that can occur in reduced concentrations in cultivated soils, possibly due to leaching processes.

Figure 2.2 shows mean ^{137}Cs and ^{226}Ra concentrations from cultivated and uncultivated surface soils, subsoils, and deposited channel sediment samples collected from the lower reaches of the Brisbane and Logan Rivers, upstream of their tidal estuaries. The mean sediment sample values lie between the mean cultivated surface soil and subsoil values, while the mean uncultivated surface soil value lies well away from this group. Assuming that the mean sediment concentrations are a linear mix of the two primary sources, then we can estimate that about 75 ± 20% of the sediments originate from subsoil (channel) erosion in the Brisbane and Logan catchments, while the remaining 25% comes from cultivated surface soils. These results do not exclude the likelihood that some sediment is also coming from uncultivated land, however, the contribution is relatively small.

NEW TECHNICAL REPORT

THE STATUS OF CATCHMENT MODELLING IN AUSTRALIA

by

Frances Marston
Robert Argent
Rob Vertessy
Susan Cuddy
Joel Rahman

Report 02/4

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

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

Copies are available through the Centre Office for $27.50

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The results of the erosion process tracing indicate that most of the sediment delivered to the lower reaches of Moreton Bay's two main catchments originates from channel erosion, supporting the model's main prediction. Hillslope erosion on cultivated land in the Lockyer, Bremer and Logan catchments is the other main source of sediment. The relative amount of sediment derived from hillslope erosion on uncultivated land is low, although, in the upper Brisbane catchment this source makes a detectable contribution. Our results from the coastal catchments show that channel erosion is the dominant sediment source, the exceptions being the Noosa and Maroochy catchments.

Model predictions about where the sediment is coming from

What we found:

- Wivenhoe Dam traps more than 95% of sediment from upper the Brisbane River
- Model predictions indicate that the middle reaches of the Logan, and lower reaches of the Brisbane catchments are important source areas
- About 70% of the sediment comes from less than 30% of the catchment area

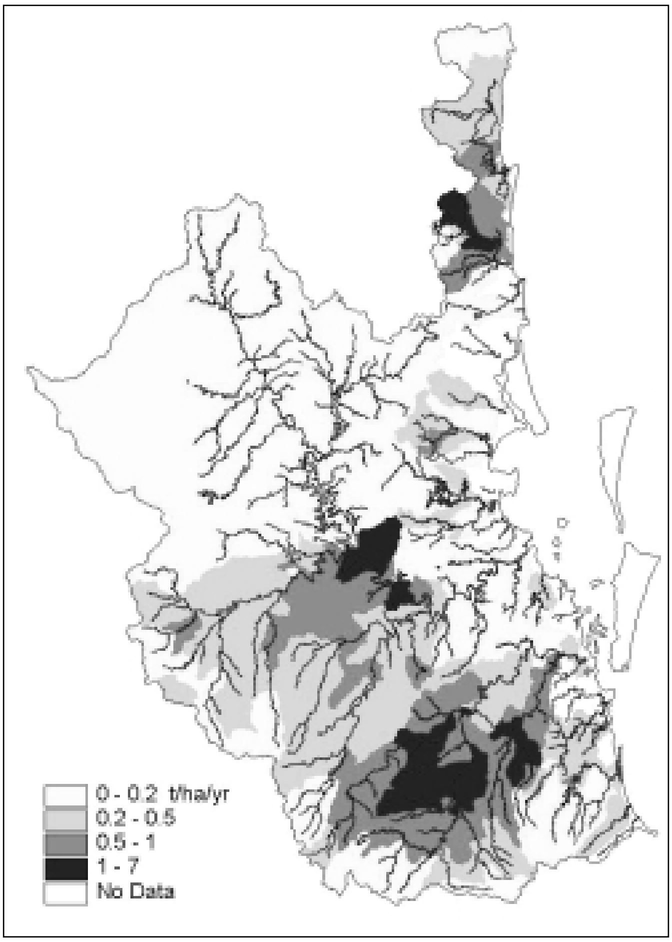

Figure 2.3 SedNet predictions about the sediment contributions of link areas to suspended sediment delivered to the most downstream points in South East Queensland's rivers.

A lot of eroded sediment is deposited and stored for lengthy periods before reaching the final receiving basin. Deposition of sediment means that the sediment yield per unit catchment area decreases with increasing catchment size. For suspended sediment the main places of net accumulation are floodplains and reservoirs. There is a low probability of sediment being transported from its source to the coast if there is significant deposition along the way. Thus the delivery of sediment downstream depends on the extent of floodplains and the proportion of total suspended load that is transported over the floodplains. This varies considerably from one place to another. Knowledge about sediment transport and deposition along river systems is therefore crucial to the management of sediment delivery to coastal estuaries and Moreton Bay.

A key SedNet output is the contribution from each internal sub-catchment to the mean annual load at the river mouth. This is predicted in tonnes/ha/y of sediment generated in each internal sub-catchment. An internal sub-catchment is that area of land which contributes sediment directly to a river reach, as distinct from that delivered via tributaries. That is, the model predicts how much sediment delivered to the river from stream bank, gully, and hillslope erosion in a river reach that is ultimately delivered to the end-point of the drainage system. The amount of sediment contributed to the coastal estuaries is a product of sediment delivery to the sub-catchment from further upstream, and the probability of that sediment passing through each downstream sub-catchment on the way to the end of the river system.

The model predictions for South East Queensland are shown in *Figure 2.3*. The most conspicuous outcome of the model is the very low sediment delivery from the upper Brisbane River catchment. This is because we estimate that Wivenhoe Dam traps more than 95% of the sediment delivered to it, effectively cutting off the sediment supply from the upper catchment to the lower reaches of the Brisbane River. This does not mean, however, that erosion is not occurring in the catchment above Wivenhoe.

It is also apparent that the most upland and lowland parts of the Logan and lower Brisbane catchments contribute relatively little sediment to the lower reaches of the rivers. A lot of sediment eroded from steeper upland areas is likely to be stored in channels and on floodplains in the lower gradient parts of the drainage system immediately downstream. The most lowland parts of the catchments generate relatively little sediment because of the low gradient.

The modelling predicts that about 70% of the sediment is generated from subcatchments that occupy less than 30% of the total catchment area. Management strategies to reduce sediment production can be targeted at channel erosion, and erosion from cultivated land in these areas. Results of sediment source tracing presented in the next section give a clearer indication about where these areas are in the Brisbane and Logan catchments.

What the sediment source tracers tell us

What we found:

- The Brisbane River is the main source of fine sediment deposited in Moreton Bay
- Soils developed on the Marburg Formation are the main source of sediment in Moreton Bay and at the mouth of Logan River

The chemical properties of sediments can be utilised to determine their origins at small to very large spatial scales, such as Moreton Bay's catchments. Any chemical property that differentiates potential sources can be used to trace sediment. This includes major and minor elements, as well as trace elements. Soils developed on major rock types normally have distinct geochemical signatures, as do the sediments derived from them. Geochemical tracing therefore involves sampling all of the major source types, and determining the relative source contributions in the resultant mix of sediment deposited further downstream in a river, estuary, or bay.

Samples were collected from soils developed on all of the major rock types in the Moreton Bay catchment (Figure 2.4). Soil sample measurements were then used in a mixing model to estimate the relative contributions of the sources to the fine sediment deposited in the Bay. The model showed that the dominant source of sediment (more than 80%) is soils developed on Marburg Formation rocks. This outcome confirms that the fine sediment deposited in the central and southern parts of Moreton Bay comes from the Brisbane River.

Sediment collected from the mouth of the Logan River also originates mainly from the Marburg Formation (50%), but this sediment is also has contributions from soils developed on Neranleigh-Fernvale Beds (21%), and Lamington Group volcanic rocks (17%). Because soils developed on Lamington Group rocks have high in iron and phosphorus contents, this source contributes disproportionately to the total iron (30%), and total phosphorus (45%) contents of the Logan River sediments.

In summary

Our study has demonstrated the benefits of a combined modelling and tracing approach to determining sediment sources. The approaches are quite independent and have very different assumptions. Combining approaches allows corroboration of predictions. In large and complex river basins like those draining into Moreton Bay, spatial modelling provides a relatively rapid means of assessing spatial patterns of erosion and sediment delivery. These model predictions can be tested using sediment-tracing methods.

In the Brisbane and Logan catchments it is clear that channel erosion is the dominant process delivering sediment through the river network. This was predicted by the modelling, and confirmed by the results of the erosion process tracing. Results of the spatial tracing show that soils developed on Marburg Formation rocks are the main source of sediment. This outcome is consistent with the model predictions about the principal source areas of sediment delivered to the bottom of the Logan and Brisbane Rivers.

The modelling indicates that 70% of the sediment is generated from subcatchments

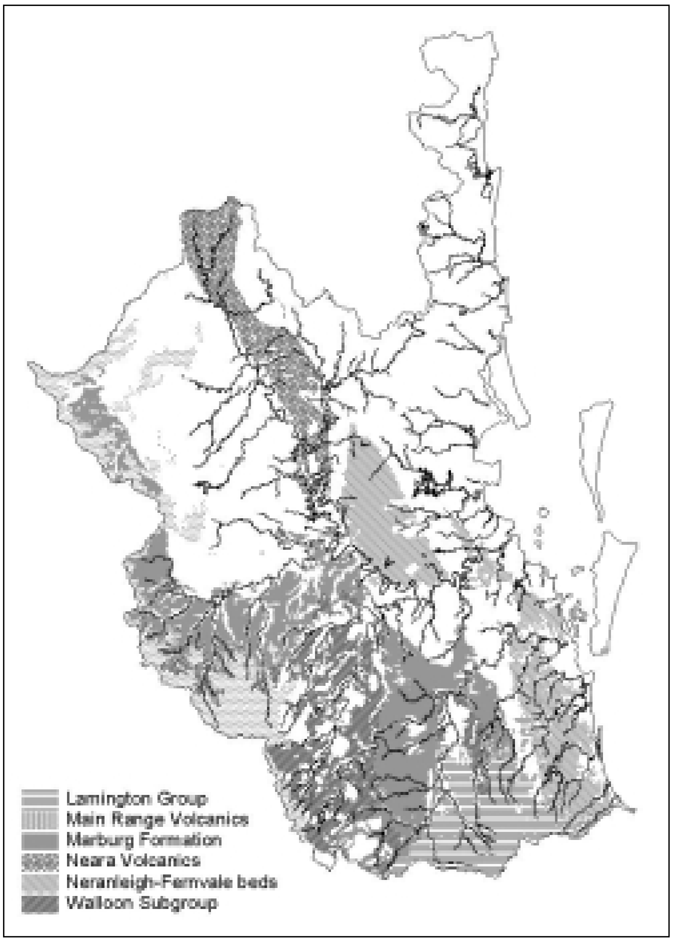

Figure 2.4 Major rock types in South East Queensland

UPDATED EVAPOTRANSPIRATION AND RAINFALL MAPS FOR AUSTRALIA

Where to get them!

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

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

They can be purchased from:

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

OR

2. Bureau Regional Offices (all capital cities) Contact details for each Regional Office are available at

http://www.bom.gov.au/inside/contacts.shtml

Information about the climate atlas map sets and the digital map data sets can also be obtained from: National Climate Centre Ph: 03 9669 4072 Email: webclim@bom.gov.au

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

Any technical queries about the mapping should be referred to Graham de Hoedt tel 03 9669 4714 email: g.dehoedt@bom.gov.au

UPCOMING TECHNICAL REPORT

THE DEVELOPMENT OF WATER REFORM IN AUSTRALIA

by

John Tisdell
John Ward
Tony Grudzinski

Report 02/5

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

Our apologies for the slower than expected publication of this report.

Advance orders are welcome.

For further details contact the Centre Office on 03 9905 2704.

that occupy 30% of the total catchment area. Tracing shows that the process to target is channel erosion, particularly in areas of Marburg Formation rock where stream bank and gully erosion have been observed. This definition of sediment sources can be used to target river and catchment restoration works to most effectively reduce sediment delivery to Moreton Bay.

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PROGRAM 3 SUSTAINABLE WATER ALLOCATION

Program Leader JOHN TISDELL

Program Leader: John Tisdell

English and Dutch Water Auction Experiments

Background

Phase two of Project 3.2: "Enhancement of the water market reform process: A socio-economic analysis of guidelines and procedures for trading in mature water markets" emphasises the development and calibration of methodologies to evaluate the potential economic outcomes of water trading utilising laboratory based experimentation. In this context, phase two of the project acts as a link between the collation and analysis of survey based data in the focus catchments of phase one and the eventual experimental simulation and analysis of catchment-specific water markets of phase three.

Experimental economics – methods and applications

Experimental economics yields a formalised, replicable approach to rapidly assess alternate policy directives, expressed as market outcomes, prior to catchment-wide implementation. The methodology provides an inexpensive means of institutional analysis coupled with substantially reduced time horizons. Well designed experiments allow for the evaluation of participant willingness to exchange, the stability of diverse institutional structures across an array of market conditions, the efficacy of policy directives and highlights potential detrimental outcomes which may compromise the reform process. The application of experimental results can provide water authorities and decision-makers with sufficiently robust information to circumvent or mitigate the consequences of inappropriate policy commitments, minimising the time for trial and error and associated social expense.

Experiments in distributing water entitlements

The first series of experiments explored the use of English and Dutch auctions to distribute water entitlements. As a result of water reforms and management, additional water may become available for extractive purposes. Examples include possible additional water arising from the re-definition of groundwater in the Goulburn-Broken and the implementation of a water allocation management plan (WAMPS) in the Fitzroy Catchment. For demonstration purposes, a water authority auction of 7000 ML of water is used to establish the initial experimental procedures. An oral English auction structure was used such that bids were made on a per unit (ML) basis. The

Table 3a Rent Seeking and Efficiency in English Water Auctions

Session No.	CS[1]	No of bids	Mean Bid $/ML	Mean Qty ML	Rent Capture[2]
Optimal	943250				1.0000
1	905860	14	129.79	500.0[b]	0.9604
2	804650	16	115.13[a]	437.5[b]	0.8531
3	808160	17	116.12[a]	411.7[b]	0.8568
4	799950	14	113.57[a]	500.0[b]	0.8481
5	807320	25	115.24[a]	280.0[b]	0.8559

Note: Mean values superscripted with the same letter are not statistically different.

[1]Consumer surplus (CS) is the value of the water to the irrigators above the price they have to pay for it.

[2]Rent capture is the amount of consumer surplus captured by the water authority through the auction system.

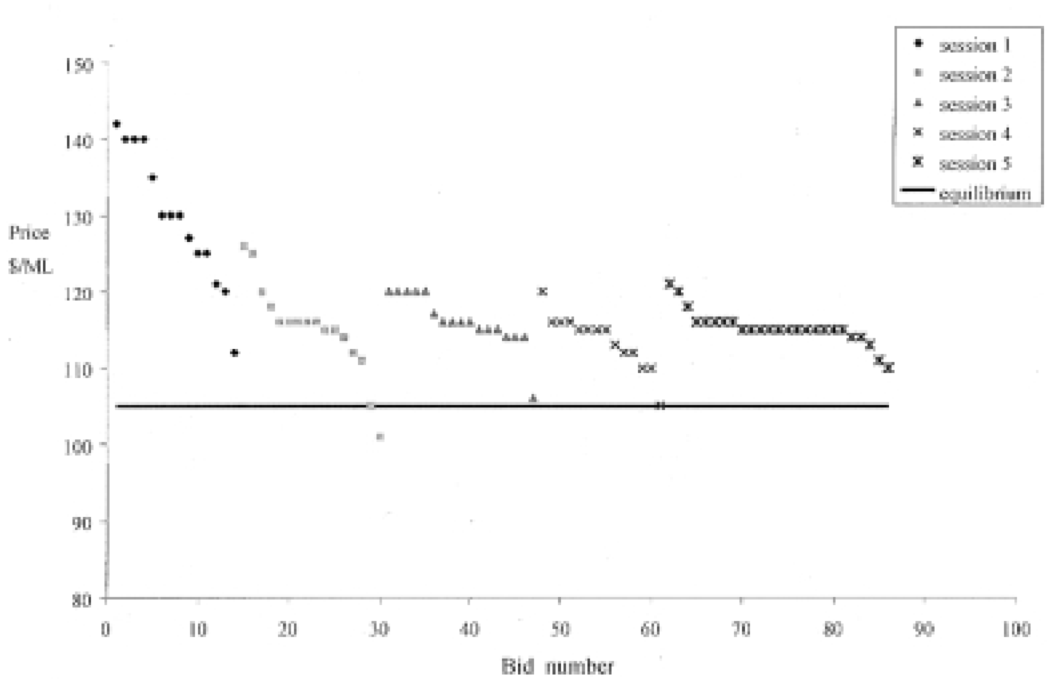

Figure 3.1 English Auction bids through time

winning bidder was allowed to purchase up to the maximum available. Remaining water was then allocated to the next auction until all the water was sold. The stated objective of the auction was to maximize the water authority's return from the water.

Results of the English auctions

The results of the English auctions are presented in Table 3a. The equilibrium price in the first session was higher than the following sessions, which had equal prices ($F=24.853$, $p<0.05$). Following the initial experiment, market efficiency stabilized at 0.85, suggesting limited learning and group strategies to minimize rent seeking by the water authority.

Elasticity of demand – English auction

The elasticity of demand for water, however, did decline through successive experiments; the number of bids and demand increased, which may well hide learning and strategic behaviour. *Figure 3.1* shows the elasticity of demand falling and demand increasing through successive sessions, suggesting that possible realisation of strategic behavior being masked by increased demand.

The auctions were conducted with a starting point of $200, with decreasing intervals of $5. A buyer stopped the auctioneer by raising his or her land and could then purchase up to the remaining volume of water at that

SPECIAL JOURNAL ISSUE ON ENVIRONMENTAL FLOWS

Australian Journal of Water Resources Environmental Flows - theory, practice and management published by the The Institution of Engineers, Australia.

Guest Editors

Mike Stewardson
Lance Lloyd
Andrew McCowan

This special issue provides eight papers and two technical notes on the subject of environmental flows. Some papers document a selection of presentations at a one-day seminar on environmental flows hosted by IEAust, the River Basin Management Society and the CRC for Catchment Hydrology held in Melbourne last November. Other papers on relevant environmental flow issues are also included.

There is limited availability of this issue. Copies can be purchased through the Centre Office for $27.50 including GST and postage and handling. Contact Virginia Verrelli on 03 9905 2704.

NEW WORKING DOCUMENT

GENERATION OF SPATIALLY AVERAGED DAILY RAINFALLS FOR THE YARRA REGION

by
Lionel Siriwardena
Ratnasingham Srikanthan

Working Document 02/1

This document describes the data preparation and the generation of areal average rainfall for the Yarra catchment.

Two daily rainfall generation models, the Transition Probability Matrix (TPM) model and a modified Wang-Nathan Model (WNM), were used to derive spatially averaged daily rainfall sequences for a region encompassing the Yarra catchment in Victoria, one of the focus catchments in the CRC for Catchment Hydrology. The performance of the two data generation models was evaluated with respect to their ability to preserve various important rainfall characteristics at daily, monthly and annual time scales.

Copies are available through the Centre Office for $22.00.

Table 3b Results of Ten Dutch Auctions

Session No.	CS[1]	No of bids	Mean Bid $/ML	Mean Qty ML	Rent Capture[2]
Optimal	943250				1.0000
1	661000	8	93.75	875	0.7008
2	655250	9	93.89	777	0.6947
3	657250	10	94.00	700	0.6968
4	665650	10	96.50	700	0.7057
5	697250	9	100.00	777	0.7392
6	675750	9	96.67	777	0.7164
7	725500	9	103.89	777	0.7691
8	762750	8	111.11	777	0.8086
9	782500	9	111.88	875	0.8296
10	731250	10	104.50	700	0.7752

[1]Consumer surplus (CS) is the value of the water to the irrigators above the price they have to pay for it.

[2]Rent capture is the amount of consumer surplus captured by the water authority through the auction system.

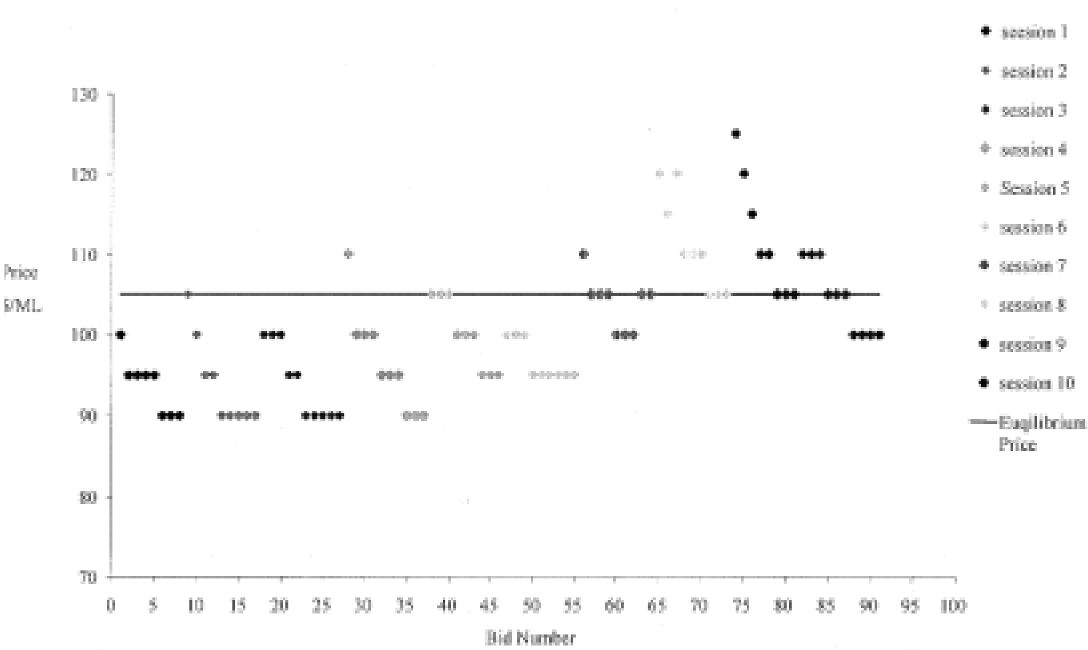

Figure 3.2 Dutch auction bids through time

price. The auction then continued until all the water was sold or the price reached zero. In contrast to the English auction that approached equilibrium from above, the Dutch auction sessions (as shown in *Figure 3.2*) approached the equilibrium from below.

Dutch auction results

Table 3b presents the level of rent capture, and mean bid and quantity for each Dutch auction session. In contrast to the results from the English auction experiments and learning, the level of rent capture increased through successive Dutch auction sessions, finally declining in the final session. The results suggest that while the Dutch prices are below competitive equilibrium (CE), prices rose through successive auctions resulting in increased rent capture. Once the trade price exceeded $130/ML prices fell in the final session.

Summary

In summary, comparing the auction structures, the English and second-price sealed-bid auction experiments showed the lowest rates of convergence to equilibrium and so the highest level of rent captured by the water authority. The Dutch auction experiments showed high rates of convergence to equilibrium and lowest rates of rent capture.

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PROGRAM 4
URBAN STORMWATER QUALITY

Program Leader
TONY WONG

Report by Margaret Greenway

Stormwater Treatment Devices – How effective are they. A Case Study, Golden Pond, Brisbane

Background

Urban stormwater runoff is recognised as a potential source of pollution to downstream waterways and aquatic ecosystems, and a component of CRC Project 4.1: "Stormwater pollutant sources, pathways and impacts" is the characterisation of stormwater pollutants and their sources.

Major pollutants in stormwater runoff include suspended solids (sediment and organic particles) and nutrients (nitrogen and phosphorus). Suspended solids increase water turbidity which reduces light penetration and photosynthesis. If there is a high proportion of organic particles then biochemical oxygen demand (BOD) increases. Nutrients are essential for aquatic plant growth however, excess soluble inorganic nitrogen and phosphorus can also cause algal blooms. Dense blooms can increase turbidity and BOD, and some cyanobacteria from such blooms are toxic.

Other potential stormwater pollutants include heavy metals, pesticides/herbicides, oils/grease and microbial

"Golden Pond" Stormwater Wetland, Calamvale, Brisbane (looking upstream towards sediment basin)

URBAN STORMWATER TECHNICAL REPORT

WATER SENSITIVE URBAN DESIGN IN THE AUSTRALIAN CONTEXT - CONFERENCE SYNTHESIS

by
Sara Lloyd

Report 01/7

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

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

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pathogens, however these substances are often more localised and their impacts on aquatic ecosystems is usually not acute.

Given the potential detrimental impacts of increased suspended solids and nutrients on aquatic ecosystems, it is not surprising that today most stormwater management strategies relate to sediment and nutrient control. CRC Project 4.2 aims to monitor the performance of stormwater best management practice (BMP).

Stormwater Best Management Practices

Structural Best Management Practices (BMP) include:

- Gross Pollutant Traps (to catch coarse sediment and trash)
- Retention Sediment Basins (to capture coarse and fine sediment)
- Vegetation Buffer Strips (sediment and nutrient removal by sheet flow across wide natural vegetation strips)
- Infiltration and Bioretention Systems (sediment and nutrient removal by filtration and biological processes)
- Vegetation Filter Strips/Grass Swales (sediment and nutrient removal along concentrated flow paths)
- Water Quality Control Ponds/Wet Basins/Wetlands (effective sediment and nutrient removal by aquatic ecosystems dominated by wetland plants).

It is therefore possible with new subdivisions and urban developments to minimise the amount of suspended

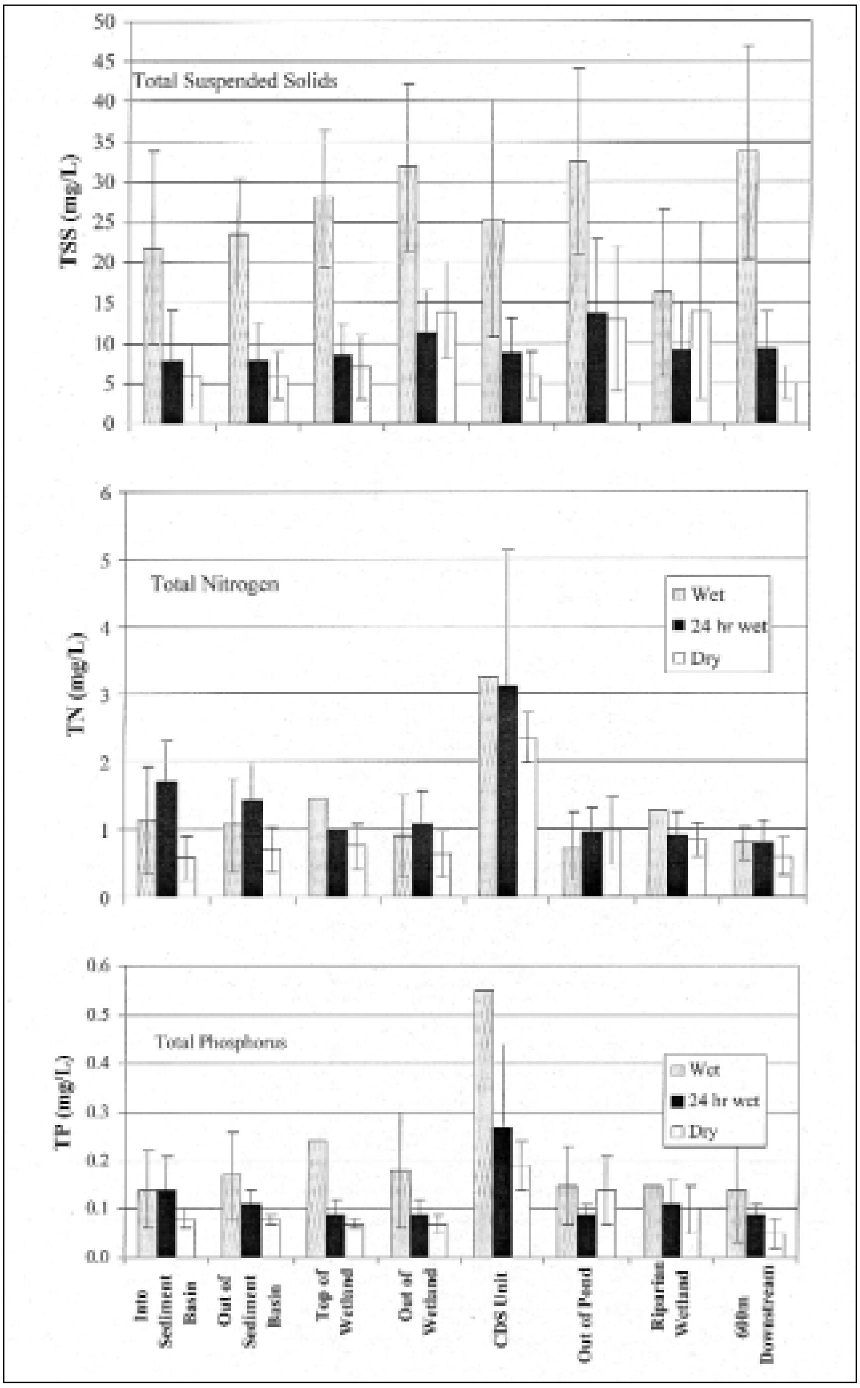

Figure 4.1. A comparison of TSS, TN and TP for samples collected within 12 hours of a storm, 24 hours of a storm and during dry weather

solids and nutrients entering downstream aquatic environments by incorporating some of these BMP. It is also possible to install Gross Pollutant Traps, Sediment Basins, Grass Swales, Wetlands and Ponds into established urban infrastructure however the constraints are greater.

Frequently asked questions are:

- "How effective are these stormwater treatment devices in improving water quality"? and
- "Is the retention of natural stream channels and adjacent riparian vegetation an effective treatment"?

In order to answer these questions, the evaluation of the performance of stormwater treatment devices for a range of conditions – catchment size, land use (percentage urban, industrial, rural), pollutant characteristics, climate (in particular rainfall), and under both wet weather and dry weather conditions - is essential.

As part of Project 4.2 a study was undertaken to investigate the effectiveness of several Stormwater Quality Improvement Devices (SQIDs) in a "treatment train" consisting of a sediment basin, a constructed stormwater wetland, a pond, a natural riparian wetland and a 600 m natural stream channel with lagoons and associated aquatic and riparian vegetation, in a residential development at Calamvale, Brisbane.

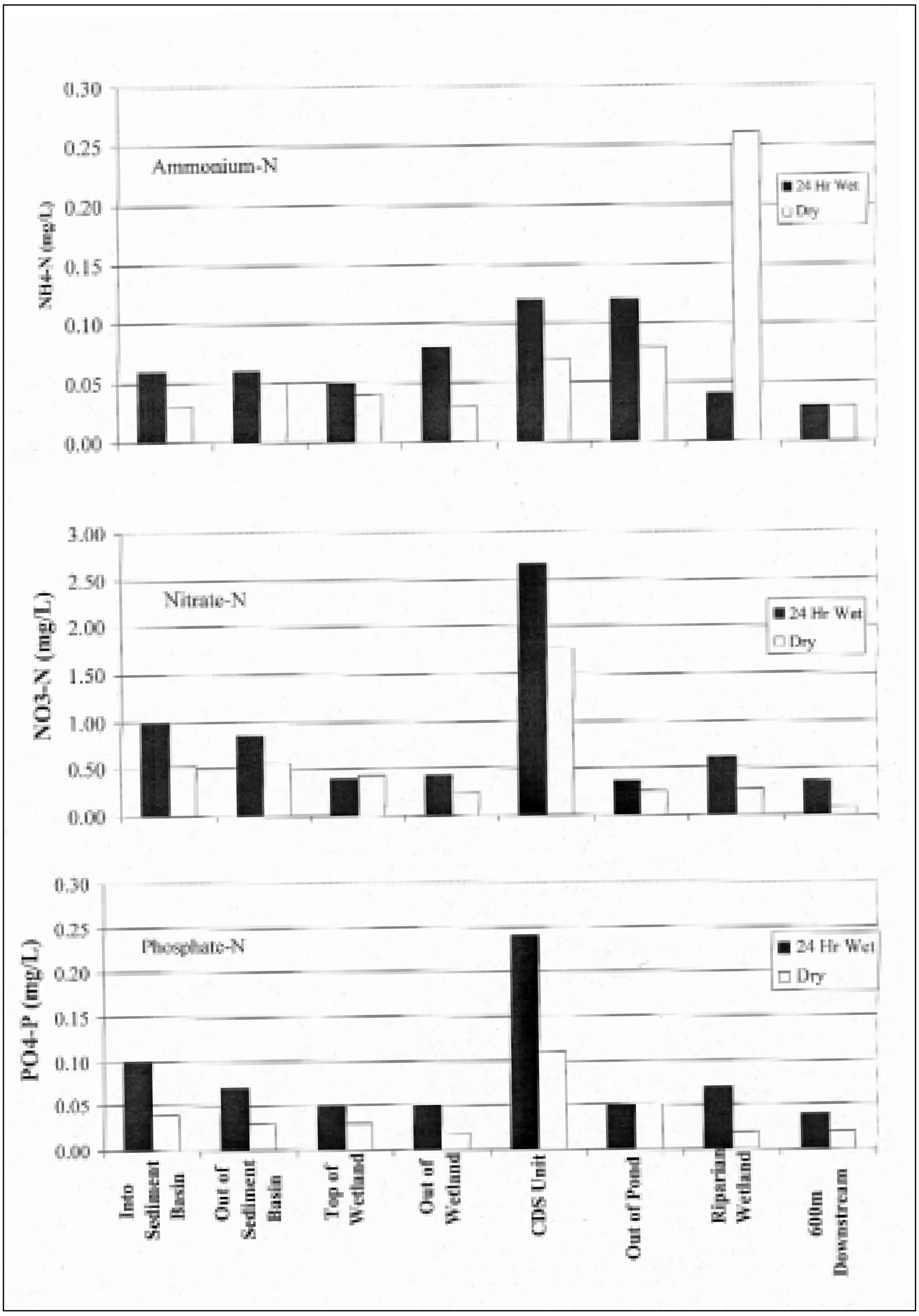

Figure 4.2 A comparison of mean nutrient concentration of ammonium, nitrate and phosphate for samples collected within 24 hours of a storm event and during dry weather

INITIAL CRC REPORT

THE CALCULATION OF STREAMFLOW FROM MEASUREMENTS OF STAGE

by

John Fenton and Bob Keller

Report 01/6

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

The main aims of the Project were to:

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

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

Copies available from the Centre Office for $27.50

NEW WORKING DOCUMENT

GENERATION OF ANNUAL RAINFALL DATA FOR AUSTRALIAN STATIONS

by

Ratnasingham Srikanthan
Tom McMahon
Geoff Pegram
George Kuczera
Mark Thyer

Working Document 02/3

The work reported here forms part of CRC Project 5.2 - National Data Bank of Stochastic Climate and Streamflow Models - of the Climate Variability Program. The literature review (CRC Technical Report 00/16) carried out as part of the project recommended an autoregressive time series model or the Hidden State Markov (HSM) model to generate annual rainfall data.

In this working document, these two models are applied to 44 stations located in various parts of Australia. The performance of the models is assessed using a number of basic and other statistics. Based on this, recommendations are made as to the appropriate model for the generation of annual data.

Copies are available through the Centre Office for $22.00.

Study area and features

- Catchment layout

The total catchment size is 235 ha consisting predominantly of residential land use and about 70% impervious surface. As a consequence of residential development the drainage infrastructure is underground drainage pipes. The northern subcatchment is 160 ha and the lower section of the main stream has been modified into a concrete lined trapezoidal channel. The stormwater then flows into a small sediment basin, a constructed wetland, and a pond, before entering the original natural stream channel in parkland. The piped western section of the catchment (13.6 ha) enters the pond via a gross pollutant trap (CDS unit). The piped south western section of the catchment (38.4 ha) enters the original riparian wetland via another gross pollutant trap (ECOSOL unit). Water from the pond and riparian wetland flows into the natural stream which has been retained for a length of 600 m.

- Sediment basin and wetland

The sediment basin and constructed wetland are retrofit features incorporating the lower 120 m of the channelised main stream and adjoining parkland. The sediment basin is a trapezoidal structure (21 m long x 13.5 m width) with 1 in 3 sloping slides and a maximum centre depth of 1.5 m. The constructed wetland is 80 m long x 15-20 m wide and 20 to 120 cm deep. It has a surface area of 1550 m^2 with a volume of 1100 m^3 at the standing water level. Percentage cover of vegetation varies between 60% (post-storm event) to 90%, of which floating leaved emergent species (Nymphaea, Nymphoides, Ludwigia) account for 77%. Submerged pond weed (Elodea) is abundant. The pond is 52 m long x 20 m wide and up to 2 m deep. 95% is completely covered with floating leaved emergent species and the submerged pond weed (Ceratophyllum) is present.

Water Quality Monitoring

- Monitoring program

Between November 2000 and March 2002 routine monthly sampling and rainfall events were monitored. Only three events were actually sampled within 12 hours of a storm, whereas seven samples were collected 24 hours after an event. Three time series events were monitored. Samples were categorised as "dry weather samples" if there had been no rainfall for a period of 72 hours or longer. Water samples were analysed for total suspended solids (TSS) and total volatile solids (TVS); total nitrogen, ammonium-N, nitrate-N, nitrite-N; total phosphorus, soluble reactive phosphate-P.

- Total Suspended Solids

During storm events (i.e. within 12 hours) TSS increased and concentrations throughout the treatment train were fairly constant indicating limited effectiveness of either man made treatment devices or natural features. Lower TSS at the end of the densely vegetated riparian wetland was partly due to the lower TSS in receiving waters from the ECOSOL unit and some natural filtration and settlement. Within 24 hours TSS was similar to dry weather concentrations and consistently below the Brisbane City Council (BCC) water quality objective of 15 mg/L. During storm events inorganic particles made up 70% of TSS, whereas during dry weather, inorganic particles accounted for 40-50% TSS. The bottom of the wetland and pond always had higher TVS than in the upstream waters and sediment basin indicating the addition of organic particulates to the water column. The 600 m length of natural stream channel was effective at removing these additional particulates. The CDS unit was effective in reducing TSS under both wet and dry conditions.

- Nitrogen

Nitrate was the major component of stormwater entering the treatment train in both wet and dry weather samples, accounting for up to 70% TN.

During a storm event organic N remained fairly constant throughout the treatment train (0.5 ± 0.1 mg N/L) but concentrations varied temporarily and spatially in 24 hour wet and dry samples ranging from 0.2-0.5 mg/L at most sites.

In dry weather samples, higher organic N was always found at the pond outlet due to a combination of high input from the CDS unit and the export of organic particulates from within the pond itself.

Nutrient concentrations of NH_4-N and NO_3-N were higher in the 24 hour wet than dry weather samples. The 24 hour samples showed that ammonium was highest at the bottom of the pond suggesting ammonification, however at the downstream site concentrations were almost undetectable. Nitrate was substantially reduced in the wetland suggesting removal by plants and autotrophic micro-organisms.

During dry weather, higher NH_4-N (0.08 ± 0.09 mg/L) at the pond outlet compared with the wetland (0.03 ± 0.03 mg/L) was probably due to additional contributions from the CDS unit (0.07 ± 0.06 mg/L) and some ammonification in the pond. The densely vegetated riparian wetland also generated high ammonium.

NO_3-N concentrations were highest in the discharges from the stormwater outlets from the CDS (1.76 ± 0.78 mg/L) and ECOSOL (1.10 ± 0.81 mg/L) units, however concentrations were reduced as the stormwater passed through the pond and riparian wetland respectively. The 600 m length of natural stream channel was effective in removing both ammonium and nitrate. BCC Water

Quality Objective of 0.65 mg/L N was most frequently achieved in the wetland and downstream natural channel.

- Phosphorus

Soluble reactive phosphate was always higher in the stormwater wet weather samples entering the sediment basin (0.01 ± 0.10 mg/L) and from the CDS unit (0.24 ± 0.19 mg/L) and ECOSOL unit (0.10 ± 0.09 mg P/L). The pond was particularly effective at removing the high PO_4 entering from the CDS unit. The downstream site always had the lowest concentrations again indicting the effectiveness of the natural stream channel, lagoons and aquatic vegetation in removing soluble nutrients. High total P leaving the pond in dry weather was due to organic particulates. BCC Water Quality Objective of 0.07 mg/L TP was most frequently achieved in the wetland and downstream natural channel.

Conclusions

From our study the following conclusions were made about the effectiveness of SQIDs at Golden Pond, Calamvale, Brisbane.

- The sediment basin was not effective in removing suspended solids, however coarse material is trapped.
- The 24 hour wet samples showed a reduction in NO_3-N and PO_4-P in the sediment basin possibly due to removal by algae on the concrete walls.
- In dry weather there was a slight (but not significant) increase in NH_4-N and NO_3-N in the sediment basin possibly due to ammonification and nitrification of dead algae or organic debris.
- The wetland was not effective in removing suspended solids in wet weather and generated small (but not significant) amounts of NH_4-N and NO_3-N.
- Reduction in all soluble nutrients occurred in the wetland and pond during dry weather indicating uptake by aquatic plants, algae and periphyton.
- The CDS stormwater outlet was a major source of soluble nutrients – these were removed by direct uptake by the vegetation and periphyton in the pond.
- The ECOSOL stormwater unit outlet was another major source of soluble nutrients – in wet weather these were removed by the aquatic plants in the riparian wetland.
- In dry weather the riparian wetland generated NH_4-N due to ammonification of organic matter.
- The 600 m length of remnant natural channel, lagoons and associated vegetation was the most effective treatment device for water quality improvement.
- The retention of natural stream channels and buffers of riparian vegetation are probably the Best Management Practice for urban stormwater treatment in many catchments.

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PROGRAM 5
CLIMATE VARIABILITY

Program Leader
TOM McMAHON

Report by Sri Srikanthan and Tom McMahon

Program Overview

Project: 5.2 National data bank of Stochastic climate and streamflow models

Model applications

The evaluation of annual rainfall data generation models was described in earlier issues of *Catchword*. It was reported that an AR(1) model and Hidden State Markov (HSM) model performed equally well in preserving most of the characteristics of annual streamflow data.

The AR(1) model is simple and easy to apply. This model has been incorporated into the Tarsier framework by Joel Rahman and Shane Seaton. In addition, work is underway to be able to generate annual rainfall data at any point in Australia. Penny Handcock (CRC for Catchment Hydrology vacation student) has been working on this project for the last two months. Initially a set of 360 high quality rainfall stations are being used to fit the parameter surfaces.

Preliminary results indicate that the error in interpolating values is large as the number of stations is too few to cover the whole country. We are in the process of getting the parameters for a larger set of stations. About 6400 stations have been selected for this purpose. These are the stations used by the Bureau of Meteorology to produce the mean monthly and annual rainfall maps. Once surfaces are fitted to parameters from this extended set of data, annual rainfall data can be generated for any point in Australia.

Daily time scale models

At the daily time scale, evaluation of a number of models resulted in two models with satisfactory performance. These are the Transition Probability Matrix model with Boughton's correction (TPMb) and the modified Wang-Nathan (WNm) model.

The only differences between the two models are that TPMb preserved the daily rainfall on solitary wet days and on wet days bounded by one side by another wet day, while the WNm model preserved the correlations between the monthly rainfall better than the TPMb model.

NEW WORKING DOCUMENT

APPLICATION OF HIDDEN STATE MARKOV MODEL TO AUSTRALIAN ANNUAL RAINFALL DATA

by

Ratnasingham Srikanthan
Mark Thyer
George Kuczera
Tom McMahon

Working Document 02/4

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

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

Copies are available through the Centre Office for $22.00.

CONFERENCE PROCEEDINGS

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

27-29 August 2001

Brisbane, Queensland

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

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

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

Generating runoff

To identify the better model in terms of generating runoff, these two models have been used with a simple rainfall-runoff (SIMHYD) model. Lionel Siriwardena has been employed for this task. Eight catchments were selected from various parts of Australia with areas varying from about 50 to 700 km^2. One hundred replicates of daily rainfall data have been generated by using the two daily rainfall data generation models. The generated data have been run through the rainfall-runoff model to produce the runoff. Several statistical characteristics were calculated to compare the performance of the models. The outcome from this exercise will be published as a CRC for Catchment Hydrology Technical report.

Other activities

Professor Geoff Pegram was with us for six weeks in February-March 2002. Senlin Zhou has been working applying the String of Beads Model (SBM) to the Yarra catchment. The model uses both the rain gauge and radar data to generate 10-minute rainfall in space and time. The results from this work will be reported later.

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PROGRAM 6 RIVER RESTORATION

Program Leader IAN RUTHERFURD

Report by Brett Anderson

On fluvial resistance…

Introduction

One of the fundamental properties of stream channels is the stage-discharge relationship.Predicting this relationship is important for many aspects of the stream rehabilitation program. It is also central to a Land and Water Australia funded Associated Project in Program 6 that is developing a roughness handbook for Australian streams. For example, a roughness estimate is needed when using Manning's equation to estimate discharge in constructed or modified channels.

In my project I am investigating the effect of riparian vegetation on catchment scale flood behaviour. In order to do this I need to be able to estimate the contribution of vegetation to the overall flow resistance of a channel and its floodplain.

Predicting channel resistance has had hydraulicians scratching their heads for centuries, and still today resistance estimation is more art than science. However, do not despair, some useful tools and techniques do exist and this article describes some of the approaches available. It is also noted that Associate Professor Bob Keller of the CRC for Catchment Hydrology observed that errors in the estimation of resistance are responsible for around two thirds of the error in flow profile calculations.

Our understanding of the resistance phenomenon is still incomplete, so while many of the methods have a theoretical basis, all are substantially derived using empirical data. In using these methods, an appreciation of the physical processes at work is vital so the user can reality-check the black box output. Therefore, before getting to the tools, a brief fluid mechanics refresher is in order.

What causes resistance?

Resistance to the movement of water is due either to frictional losses at a boundary surface, or to energy dissipated by turbulent structures with the flow (for instance kolks, boils, and secondary flows). The boundary can be separated into two distinct zones: the wetted perimeter and the free surface. These, along with internal flow turbulence, give three different energy loss zones to consider.

- The wetted perimeter

  At the wetted perimeter there is a layer of stationary fluid, the water molecules in this layer are trapped by microscopic roughness of the solid surface. This phenomenon causes a boundary layer to form, in which flow velocity is lower than in the free stream due to friction losses at the solid surface. Boundary layer resistance in rivers varies primarily with the height of roughness elements at the solid surface, and is often correlated with the grain size of bed particles.

- The free surface

  Usually the interaction between the atmosphere and a river's free surface is weak by comparison with that around the wetted perimeter. However, significant resistance is induced where large wave forms are generated. Breaking waves, such as through rapids, and at the terminus of a water chute, dissipate energy by inducing strong flow turbulence and air entrainment.

- Internal flow turbulence

  The most efficient way for water to flow is in a straight line, any deviation results in energy loss which is measured as flow resistance. Deviations are most commonly recognised as flow turbulence, which has many forms but is a ubiquitous feature of natural river flows. Flow turbulence dissipates energy via molecular-scale momentum transfer through the action of viscous forces known as Reynold's stresses. Examples are: separation zones on the lee side of solid objects such as tree trunks and large rocks; turbulent fields generated as flow passes through porous zones such as the branch-leaf complex of a shrub; and helical secondary flow observed at channel bends.

Tractable analytic theories describing turbulence phenomena are an active research topic, for the moment we rely largely on two approaches:

(i) Extending well verified results obtained for relatively simple flow situations, such as drag relationships for cylinders and flat plates, and applying these to more complex scenarios; and

(ii) Developing accurate process descriptions by characterising the primary temporal fluctuations and spatial dynamics, and estimating energy dissipation by applying approximations such as the Boussinesq formulation for eddy viscosity.

Resistance coefficients

Three different resistance coefficients have been regularly applied for a century or more to quantify flow resistance, namely f, n, and c, which are respectively the Darcy-Weisbach (f), Manning (n) and Chezy (c) coefficients. Each provides a link between channel properties and flow velocity with a single coefficient.

The following equation expresses these relationships and demonstrates that the coefficients are essentially interchangeable.

$$\frac{U}{u^*} = \sqrt{\frac{8}{f}} = \frac{R^{1/6}}{n\sqrt{g}} = \frac{c}{\sqrt{g}}$$

where:

u^* = mean shear velocity $\quad u^* = \sqrt{gRS_f}$

U = mean velocity $\quad R$ = hydraulic radius

S_f = friction slope $\quad g$ = gravitational acceln

Empirical Resistance equations

- Some examples

The most common resistance coefficient employed in Australia is Manning's n. It is not always constant for a reach and often gets smaller as discharge increases, although there are many exceptions to this rule (see Hicks and Mason, 1991).

Some commonly applied equations for estimating n include:

Strickler (1923) $\quad n = 0.039\, d_{50}^{1/6}$

Keulegan (1938) $\quad n = 0.035\, d_{90}^{1/6}$

Limerinos (1970) $\quad n = \dfrac{0.113\, R^{0.16}}{1.16 + 2.0 \log(R/d_{84})}$

Jarrett (1990) $\quad n = 0.32\, S^{0.38}\, R^{-0.16}$

Sauer (1990) $\quad n = 0.11\, S^{0.18}\, R^{0.08}$

[where d_{xx} relates to the bed particle-size]

Please note, the preceding regime equations and resistance equations must be applied with caution, for they have been developed for specific channel types and validated over a restricted range of conditions. The reader should consult the relevant reference before attempting to apply any of these relationships. An excellent review of techniques in flow resistance estimation is also provided by Duncan and Smart (1999).

- Descriptive methods

Probably the most commonly applied method of resistance estimation is based on experience or professional judgement. Where the subjective estimation of energy loss parameters is founded on substantial experience with well-gauged reaches this approach can be expected to yield quite reliable results. However, there will always be situations where conditions outside the range of experience are encountered.

Attempts to capture such experience are exemplified by the approach of Cowan (1956). This method utilises tables of n-values, provided in Chow (1959). The two steps in this approach are:

(i) Determine the contributions to the total energy loss parameter due to the components: basic boundary roughness; degree of irregularity of boundary; variations of channel cross-sections; and the relative effect of obstructions and vegetation.

CRC TOOLKIT WEBSITE

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

Potential users are invited to learn more about the Catchment Modelling Toolkit by visiting www.catchment.crc.org.au/toolkit

From the Toolkit site you can subscribe to receive updates and other information as the Toolkit Project progresses.

For further information contact

David Perry on 03 9905 9600 or email david.perry@eng.monash.edu.au

NEW TECHNICAL REPORT

STOCHASTIC GENERATION OF ANNUAL RAINFALL DATA

by

Ratnasingham Srikanthan
George Kuczera
Mark Thyer
Tom McMahon

Technical Report 02/6

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

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(ii) Add the components and multiply by a factor to allow for the degree of meandering.

Unfortunately the tables fundamental to this approach are not rigorously based on the results of experiments and prototype observations. Therefore this method is not widely used today and needs to be applied with caution.

- Visual Comparison

The easiest way to describe the overall characteristics of a river reach is by comparison of the target reach with a set of photographs of streams with known roughness. While this approach is not quantitative it does allow different types of streams to be identified, and stream settings differentiated.

There are three collections of photographs which are widely used to estimate n-values. The first is contained in Chow (1959). It should be noted that, out of the 24 photographs shown, only the last one relates to a natural river, the others all depict artificial channels of fairly regular section and alignment.

The second collection was published by the United States Geological Survey (Barnes, 1967). It covers fifty different channels and streams, giving two photos per stream, plus a channel description and some typical cross-sections.

The third and most recent photographic reference comprises information on the physical and hydraulic properties of 78 reaches of rivers and canals in New Zealand (Hicks and Mason, 1991).

Together, the information presented by Chow, Barnes, and Hicks and Mason represents a major database to guide practitioners and will be appropriate for many Australian streams. However, regular *Catchword* readers would also be aware that there is an Associated CRC for Catchment Hydrology project underway to produce a similar guide for Australian streams (funded by L&WA). Stay tuned!

A final word

Resistance estimation in the absence of calibration data (i.e. known flow levels and discharges) is a dangerous exercise. The recommended approach is to estimate flow resistance using several of the methods described above, in combination with real data, to provide a reality check for flow profile predictions.

References

Barnes, H. H. (1967) *Roughness characteristics of natural channels* United States Geological Survey Water Supply Paper 1849

Bray, D.I. (1982) *Flow resistance in gravel-bed rivers.* In Gravel-bed Rivers, Ed. Hey, Bathurst & Thorne, Wiley, 109-137

Chow, V. T. (1959) *Open Channel Hydraulics*, McGraw Hill, New York.

Cowan, W. L. (1956) *Estimating Hydraulic Roughness Coefficients* Agricultural Engineering **37**, 473-475

Dingman, S. L. and Sharma, K. P. (1997) *Statistical development and validation of discharge equations for natural channels* Journal of Hydrology **199**, 13-35

Duncan, M. and Smart, G. (1999) *Flow Resistance: An overview of formulae for alluvial channel flow estimation* National Institute of Water and Atmospheric Research Institute Ltd Napier, New Zealand, pp.11

Hicks, D. M. and Mason, P. D. (1991) *Roughness Characteristics of New Zealand Rivers*, Water Resources Survey, Wellington, NZ.

Jarrett, R. D. (1984) *Hydraulics of High-Gradient Streams* Journal of Hydraulic Engineering 110, 1519-1539

Keulegan, G.H. (1938) *Laws of turbulent flow in open channels.* Journal of the National Bureau of Standards, Research Paper 1151, 21, 707-741

Limerinos, J.T. (1970) *Determination of the Manning coefficient from measured bed roughness in natural channels.* U.S. Geological Survey Water Supply Paper 1898-B. pp.47

Sauer, V.B. (1990) U.S. Geological Survey, written communication, In: Coon, W.F. (1998) *Estimation of roughness coefficients for natural stream channels with vegetated banks.* U.S. Geological Survey Water-Supply Paper 2441, pp.133

Strickler, A. (1923) *Beitrage zur flage der geschwindigheitsformel und der rauhigkeitszahlen fur strome, kanale und geschlossene leitungen.* Mitteilungen des eidgenossischer Amtes fur Wasserwirtschaft, Bern, Switzerland, n. 16.

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PROGRAM 7

COMMUNICATION AND ADOPTION

Program Leader

DAVID PERRY

Report by David Perry

The Flow on Effect – April 2002

AT A GLANCE – A SUMMARY OF THIS ARTICLE

A series of CRC industry seminars targeting urban stormwater managers will be held during mid-May 2002. The seminars will highlight recent advances in urban stormwater modelling and will demonstrate MUSIC, a decision support system for urban stormwater management. The cost for participants is $33 and registration forms are available from the Centre Office or from www.catchment.crc.org.au/news

Many CRC projects are now in their third year and the dividends of our research are starting to become much clearer. Catchment-scale CRC products for land and water managers are beginning to take shape, and in some cases, are being released.

National Roadshow – Industry Seminar Series: Urban Stormwater Quality

The Urban Stormwater Quality Research Program (Program 4) led by Tony Wong is the first of the current CRC research programs to embark on a national 'roadshow' to highlight research outcomes and their applicability to urban stormwater managers. This is being done under the banner of our 'Industry Seminar Series'.

User access to CRC products

The CRC's Industry Seminar Series began in response to requests from potential users for access to the CRC's research advances - access in a form that focused on the needs of land and water managers. The Series aims to bridge the traditional gap between research outcomes and industry practice by delivering research in a practical, real world and integrated context. Over the last four years, the CRC has organised 14 Industry Seminars with locations including Perth, Adelaide, Melbourne, Bermagui, Canberra, Sydney, Taree and Brisbane. Our experience shows that this style of communication is a very effective one – and it will certainly meet the Urban Stormwater Quality Program's communication objectives.

Decision Support System - MUSIC

A key objective of the Urban Stormwater Quality research team has been to create a decision support system (DSS) that packages the results of many research activities undertaken at the CRC for Catchment Hydrology and other organisations into an easily used tool. MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is the result of that strategy and enables urban catchment managers to:

(a) Determine the likely water quality emanating from specific catchments

(b) Predict the performance of specific stormwater treatment measures in protecting receiving water quality

(c) Design an integrated stormwater management plan for each catchment, and

(d) Evaluate the success of specific treatment measures, or the entire catchment plan, against a range of water quality standards.

Two CRC Parties closely involved in urban stormwater management, Melbourne Water and Brisbane City Council, have tested the beta version of MUSIC and provided feedback for development of later versions.

Timetable for Seminars

The CRC Program 4 team is now poised to communicate the range of research outputs that have been delivered in the Program so far and to highlight the potential application of MUSIC. Over this year, the Program 4 team will be delivering a number of seminars and MUSIC training courses around Australia. The first 'round' of these seminars entitled 'Urban Stormwater Quality Modelling' are scheduled for mid May 2002 targeting urban stormwater managers followed by training courses in July 2002. All *Catchword* subscribers will have recently received a registration form with the March 2002 issue.

The series scheduled for May comprises five Industry Seminars:

- Canberra - Wednesday 8 May 2002 - National Convention Centre, Canberra
- Sydney - Thursday 9 May 2002 - Powerhouse Museum, Ultimo
- Brisbane - Friday 10 May 2002 - 80 George Street, Brisbane
- Melbourne - Monday 13 May 2002 - Hotel Sofitel, Melbourne
- Adelaide - Tuesday 14 May 2002 – SARDI Plant Research Auditorium, Waite Research Precinct, Urrbrae

These seminars will focus on the needs of those involved in urban catchment management, including the protection of urban aquatic environments, planning and design of urban stormwater management measures, land development and water sensitive urban design.

INDUSTRY SEMINAR SERIES

URBAN STORMWATER QUALITY MODELLING

This CRC for Catchment Hydrology Industry Seminar Series presents the results of research undertaken by the Urban Stormwater Quality Program and the development of MUSIC (Model for Urban Stormwater Improvement Conceptualisation).

9.00am - 12.35pm

CANBERRA	**Wed 8 May 2002**
SYDNEY	**Thu 9 May 2002**
BRISBANE	**Fri 10 May 2002**
MELBOURNE	**Mon 13 May 2002**
ADELAIDE	**Tue 14 May 2002**

Cost is $33.00 (including GST, coffee, tea and cake).

For registration forms and further details visit www.catchment.crc.org.au/news or contact the Centre Office:

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Seminar Leader

The seminar will be led by Tony Wong and will commence with a general overview of urban stormwater quality management. He will outline the attributes of Water Sensitive Urban Design, and current complexities in assessing the benefits and opportunities for implementing a range of stormwater treatment measures.

Speakers

Speakers from the CRC's Urban Stormwater Quality research program will then present research results that support improved operation and performance of vegetated swales, bioretention systems, constructed wetlands, and ponds. A description and demonstration of MUSIC will follow and then an industry representative will then describe their experience in applying MUSIC for urban stormwater planning and management.

The seminar will conclude with a summary of the CRC's future research directions aiming to enhance the capability of MUSIC in developing and evaluating integrated urban stormwater management strategies.

Cost and registration

The seminar costs $33 (including GST and coffee, tea and cake for morning tea). A registration form can be downloaded from our web site at www.catchment.crc.org.au/news

Additional registration forms and further details can be obtained from:

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Email: crcch@eng.monash.edu.au

Registrations must be received by close of business on Tuesday 30th April 2002

Acknowledgement of sponsors' support

In order to keep the costs down for participants a number of organisations have generously offered their support for these seminars. I would like to thank each of the following sponsors for their substantial contributions and assistance:

- Brisbane City Council
- Ecowise Environmental
- Melbourne Water
- Patawalonga Catchment Water Management Board
- Torrens Catchment Water Management Board

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The CRC for Catchment Hydrologys website www.catchment.crc.org.au

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There is a wide variety of useful links to other websites including water focused email groups/servers etc.
www.catchment.crc.org.au/links

User information about many models developed by the CRC, and in some cases the actual model software, can be downloaded from the CRC models page
www.catchment.crc.org.au/models

You can receive up to date emails about activities the CRC is involved in e.g. recently published reports and upcoming workshops and seminars etc.
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The events calendar on the website provides details of upcoming key events in the field of hydrology and related disciplines each month
www.catchment.crc.org.au/events

All of the CRC project description sheets are on the website as pdfs.
www.catchment.crc.org.au/programs

All CRC staff have their contact details listed on-line in a database – the CRC staff directory is also available for downloading as a Adobe Acrobat file
www.catchment.crc.org.au/contact

The CRC website is designed as a resource for those who want information about the CRC's research and its application

For further information contact David Perry on 03 9905 9600 or email david.perry@eng.monash.edu.au

POSTGRADUATES AND THEIR PROJECTS

Our Profile this month is David Newton

Background

The year was 1987; Bob Hawke was Prime Minister and tertiary education was free. As a fresh-faced 17-year-old I burbled off in my 1970 XY Falcon to begin four years of civil engineering at the University of Queensland. Initially I wanted to build sky-scrapers, bridges and dams (who didn't?). However, under the tutelage of Colin Apelt, Lew Isaacs and the enigmatic Derek Brady, I soon developed a keen interest in water.

After graduation I was fortunate to obtain employment with Water Studies Pty Ltd, a Brisbane-based specialist consulting firm lead by Drs Chris Joy and Sharmil Markar. My work with Water Studies consisted primarily of hydrologic and hydraulic modelling which I enjoyed very much. With the encouragement and support of my employer I was also able to complete a Master's degree part-time at the University of Queensland.

In response to what I can only assume is an early mid-life crisis, I decided that I needed a change. After 10 years with Water Studies I accepted the offer of a CRC PhD scholarship from Griffith University in the Urban Stormwater Quality Program under the supervision of Drs Graham Jenkins and Ian Phillips. They say you don't have to be crazy to start a PhD with a wife, a mortgage and two children – but it sure helps.

My research project is concerned with evaluating the effectiveness of porous pavement as a stormwater treatment device for impervious area runoff. Porous pavement has been available in various forms since the 1970s and has been successfully implemented in a number of countries, primarily to deal with urban flooding problems. The evolution of urban stormwater management to include the removal of pollutants as a primary objective has lead to renewed interest in porous pavement. However, to overcome some of the structural limitations of porous pavement, the focus has shifted towards its use in conjunction with, rather than as an alternative to, impervious pavement.

A wide variety of porous pavement options is available, each with advantages and disadvantages for various applications. The common features of all porous pavements include a permeable surface layer overlying a reservoir storage layer. The surface layer of porous pavement may be either monolithic (such as porous asphalt or porous concrete) or modular (clay or concrete blocks). The reservoir storage often consists of a layer of crushed stone some 200 mm to 500 mm thick and is used to store water before it is discharged to the underlying soil or laterally towards a piped drainage system.

Modular porous pavements with a sealed base and sub-surface drainage system have several advantages over alternative configurations. These advantages include a lower rate of clogging than monolithic pavement structures and reduced susceptibility to differential settlement associated with variations in sub-grade moisture content. Somewhat surprisingly, such systems have been shown to be capable of significantly reducing runoff volume; an important but not yet widely adopted measure of stormwater management effectiveness. My research is concerned with quantifying and predicting stormwater quality and quantity treatment processes in this type of pavement.

My project has two principal components:

- estimating evaporative water loss (the only mechanism for volume reduction in a sealed system) from modular "lattice" pavements
- assessing the pollutant removal effectiveness within the pavement structure

The evaporation studies are based on 14 experimental pavement models featuring coarse granular media of different grain sizes. To investigate the effect of water availability on evaporative losses, half of these pavement models include permanent water storage. The data from the pavement models will quantify the sensitivity of runoff volume to the size of granular material within the lattice voids, as well as the potential increase in evaporation associated with extended detention. This data will also provide the basis for development of a water balance model capable of predicting expected runoff volumes.

The pollutant removal studies will be based on a detailed investigation of sub-surface hydraulics and pollutant removal through an experimental pavement structure. The principal objectives are to determine the sensitivity of particle removal to hydraulic loading, the impact of unsteady flow conditions on these results and the effect of biofilm growth within the pavement structure on the removal of dissolved nutrients. The combination of the results from the water quality and quantity investigations will provide the basis for evaluating the stormwater management effectiveness of porous pavement relative to the contributing impervious catchment area.

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SUSTAINABLE WATER ALLOCATION REPORT

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

by

John Tisdell
John Ward
Tony Grudzinski

Report 01/1

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

Copies available through the Centre Office for $27.50.

CRC PROFILE

Our CRC Profile for March is:

John Ward

My current professional and research interests are:

1. CRC research involving laboratory and field experiments to test irrigator attitudes to, and performance in, water markets according to the type of market structure and the level of environmental information provided. The outcomes are measured as the aggregate experimental income of participants, distribution of simulated income and the divergence of resulting abstraction volumes from natural flows. The developed software and protocols are seen as a primary educational instrument as well as providing a rapid, formalised and repeatable tool for water managers and policy makers.
2. Sensitivity analyses of economic valuations of non-market goods and services, e.g. the aesthetic value of riverine environments, preservation of water quality to enhance endemic fish populations, recreational value of natural areas.
3. Comparing the environmental outcomes of free market economic systems and those conditioned by Buddhist principles and precepts. This has extensions to the notion of the establishment of binding social contracts and community governance of natural resources managed as common property. The potential autonomy, synergies and tensions of community governance within current institutional frameworks are also being explored using experimental methodologies developed as part of the current CRC research. Australian river systems are employed as case studies.
4. Developing a GIS appraisal methodology which accounts for spatial, ecosystem, vegetation assemblage and socio-economic variables. Potential application as a planning tool at the local government jurisdiction, enabling the quantification and analysis of the impacts of development on remnant ecosystems.

Currently I am teaching undergraduate and Masters level environmental economics, research methods ands statistics and the economics of natural resources.

I have a Ph.D. in environmental economics, specifically the economic value of recreation and logging in selected NSW native forests, although my original degree was a B.Sc. in molecular and developmental biology.

From 1979 to 1995, I owned and managed my own timber production companies in NSW and the USA. I also teach the martial arts of Aikido and Iiado (Japanese sword).

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WHERE ARE THEY NOW?

Report by Jai Vaze

Background

My PhD study was part of the CRC's Urban Stormwater Program, and I completed my PhD titled "Pollutant buildup and washoff in urban areas and the modelling of urban stormwater pollutant load" in a bit over three years. The comments from both the thesis reviewers were very encouraging and the credit goes to my supervisors; Francis Chiew, Tom McMahon and Ian O'Neill. I would also like to thank Rodger Grayson, Tony Wong, Hugh Duncan and Senlin Zhou for their guidance from time to time and all the members of the department of Civil and Environmental Engineering, University of Melbourne for being so friendly and cooperative. The University of Melbourne and the CRC for Catchment Hydrology funded me through my course of study.

Work with DLWC

During my PhD, I took leave of absence for five months and worked for the Department of Land and Water Conservation (DLWC), NSW as a consultant on a project: The Project "Management of key grazed native grass communities in the Murray-Darling Basin" was funded by the MDBC. It was a good experience as I learned a lot in terms of field measurements/experimentation and modelling. In April last year, I moved to Queanbeyan and joined DLWC as a consultant. I am involved in the development of models of salt movement at different scales through the NSW landscape. I am also involved with the development of Pedo-transfer functions with the main focus on soils in NSW.

Models in use

We have implemented the first version of the model (CATSALT Version-1) on two catchments in the Central West region of NSW (Mandagery Creek and Boorowa). The modelling methodology consists of application of three different types of models – CATSALT, HYDRUS-2D and FLOWTUBE.

CATSALT is a quasi-physical model and was developed to couple landscape salinisation and stream salinity operating on a daily time step. It includes three modules:

- a lumped conceptual rainfall runoff model SMAR
- a runoff distribution component based on landuse and topography
- a salt mobilisation and washoff component.

To incorporate the effects of landuse change, the distribution methodology requires leakage rates for all soil types and landuse combinations within the catchment. These are obtained from the Richard's equation based process model HYDRUS-2D and published data. Additionally, by combining the results from HYDRUS with those from SMAR, the water balance can be confidently closed.

FLOWTUBE is a Darcian concept based groundwater flow model. The model provides information on long term shifts in groundwater flux and the associated time constants corresponding to the changes in landuse/recharge regime.

Overall approach

The approach here is to combine conceptual rainfall runoff modelling techniques with land-use efficiency indices obtained from process modelling, topographic modelling, salinity hazard and salt outbreak mapping, to investigate the effects of land-use on water and salt balance.

The technique draws its strength from a new and innovative approach of combining different techniques at the appropriate scale while allowing for heterogeneity within the catchment. Unlike conventional salinity studies that focus on groundwater alone, this study explores surface and groundwater interactions with the stream.

The results for Mandagery Creek and Boorowa catchments were presented in a workshop held at Orange in September last year. The workshop was a great success and we are currently working on CATSALT Version-2, which will be fully distributed. The output from CATSALT at a catchment scale will be fed into IQQM to assess the end-of-the-valley impacts.

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

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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

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