Aqua Australis

THE MAGAZINE OF THE HYDROLOGICAL SOCIETY OF SOUTH AUSTRALIA NO 1 VOL2

ISSN 1323-0077 *Water. Not necessary to life, but rather life itself.* - Saint-Exupery May 1996

The Hydrological Society of South Australia, c/- Water Resources Group, DENR, GPO Box 1047, Adelaide, Australia 5001

Hydsoc on the Web!

The society now has a web page. The address is:
http://www.aelmg.adelaide.edu.au/civeng/hssa/hssa.html

The page has a brief outline of the society and its office-holders as well as newsletters (including this one). Any comments or suggestions would be most welcome.

Hydsoc Constitutional Review

Bill Lipp

A sub-committee is currently reviewing the Hydrological Society's constitution. The last changes to the constitution occurred in 1986 when the Society became an incorporated body.

The main objects of the review are to

- ensure that the constitution meets the present operational needs of the Society
- clarify areas of uncertainty in the present constitution
- allow for the establishment of regional groups of the Society

The sub-committee has completed its review of the current constitution and has identified a number of desirable amendments. It is currently drafting out an additional clause to the constitution to allow for the establishment of regional groups. The changes proposed will be discussed at the next technical meeting (to be held on June 27) and it is hoped that a copy of the current constitution with the proposed amendments and explanatory notes will be circulated to all members prior to the meeting.

The sub-committee will then consider all the comments received, prior to the presentation of the then proposed amendments to the Annual General Meeting of the Society on August 22nd at which the proposed amendments will be put to the vote.

MEMBERSHIP FEES

Membership of the Hydrological Society is still only $ 10 per year (tax deductable for practitioners). Contact Bill Lipp, Treasurer, Hydrological Society of South Australia, Drainage Services Section, Department of Transport, PO Box 1, WALKERVILLE SA 5081, telephone (08) 343 2508, fax (08) 343 2747

Water Resources Act Review

Bart van der Wel

A draft bill to overhaul the Water Resources Act has been released for public comment. The bill incorporates the Catchment Management Act under which Catchment Boards have been set up.

The bill allows the Minister to devolve water resources management to local Boards similar to those operating the River Torrens and Patawalonga catchments. The South Australian Water Resources Council will be abolished, and replaced by meetings of the Board chairmans. Each Board will be required to prepare rolling plans subject to public consultation and Ministerial approval. Nevertheless, the Minister may superimpose development that the Government considers of State or National interest.

The role of the Water Resources Group of the Department of Environment and Natural Resources will be reduced to that of a policy and supervising body, and the Boards will likely obtain most technical expertise from consultants.

The Government will raise money for the Boards from levies on water users or rate payers in each Board area. Where there is no Board, the Minister may impose levy but only in Proclaimed Areas.

The Bill proposes to increase the avenues for raising funds, with possible incentives for reducing pollution or water demand.

The Bill strongly favours property rights for water and the application of market forces. The former is strongly resisted by environmental groups.

A number of areas of concern have been raised. These include management of environmental allocations, flexibility if environmental degradations become evident, speculation in water allocations and gravitation of licences from small owners to big corporations.

Submissions for draft bill close 12th July 1996

For a copy of the draft bill contact:

Julie Cann
Water Resources Group, DENR
Tel 204 9127
Fax 204 9144

Note: The next Hydrological Society technical meeting on June 27th will be addressed by Megan Dyson from the Crown Solicitors Office who was responsible for preparing the bill.

Chairman's Watering Hole

Trevor Daniell

All practitioner's in the water field welcome an integrated and holistic management approach to water resources management. We have been invited to submit any comments on the discussion paper "towards a New Water Resources Act". It is a pity we did not get the same opportunity on some of the other major water issues that have been made in SA in the last year such as the outsourcing of water supply and sewerage operations. The syndrome of "rhetoric and reality" of government always seems to raise its head when one face of government is open and inviting and the other is a closed shop, but when it happens dealing with the same resource it certainly does rile the workers in that field. As time goes on all these issues will be forgotten as long as water is still being supplied on a sustainable basis.....92c a tonne to inside the house. If you drink bottled water -- but more like $600 a tonne inside the house but you also have to carry it --- perhaps not a sustainable source. Are not marketeers wonderful. Just discuss that single issue at the next soiree without any mention of quality- I bet you have trouble. The quality of the bottled water is ?????? Welcome to integrated water resources development.

People - Mr Trevor Daniell

Chairman of Hydrological Society of South Australia

Trevor Daniell is a Senior Lecturer in The Department of Civil and Environmental Engineering at the University of Adelaide. He has a Master of Engineering from the University of Adelaide and Master of Administrative Studies from the ANU. Prior to joining the University in 1989 he spent 16 years working in most facets of hydrology, water resources and town infrastructure development. This included water supply and stormwater developments, environmental engineering projects such as the waste management codes for Uranium mining, urban lakes and wetlands. He has worked in the ACT, SA, NSW, NT, Indonesia and the Philippines and the Pacific Region. He has been a member of the National Committee of Water Engineering, and Chairman of the Hydrological Society of Canberra, IE Aust Water Panel in South Australia as well as chairing numerous flood and water resources committees and being a member of various council and coordinating committees examining strategies for the use and control of stormwater. His research interests are in environmental engineering including sustainable development issues in water, extreme flood estimation, rainfall runoff Modelling, stormwater issues and developing the use of neural networks in hydrology including water quality and consumption patterns. He has published over 60 papers on a variety of hydrological and water resource subjects.

In line with awareness of environmental issues he cycles to work, has been seen running around the Torrens Lake or swimming in the Burnside Pool. Managing Junior cricket and/or coaching Football Teams keeps him off the streets on weekends.

Riverland Group Inaugural Meeting

The inaugural meeting of the proposed Riverland Group was held on Friday 17 May 1996 at Berri. Forty six people attended which included ten from the Adelaide based Society. A good start, which has demonstrated that there is an interest here in the Riverland.

The concept of the Riverland Group is to provide a forum for technical debate on a wide range of water issues. The intention is to invite a variety of specialist speakers but to ensure that the topics are presented in an informal manner suitable for a community based audience.

The Murray Darling Association has supported the proposal to develop such a group and the Department of Environment and Natural Resources has offered to help.

Proposals to formalise the formation of the Riverland group are being negotiated with the Hydrological Society of SA in Adelaide.

It is now proposed to promote further meetings including some that have been initiated by other organisations but that have a strong water information flavour.

El Niño Good Bet to Predict Flows

Report by Bob Newman

There is a 2 in 3 chance of being able to predict good and bad natural runoff in the River Murray at Berri from the ocean temperature at Galagapos Islands off Peru, according to Professor Jim Simpson, visiting professor from Colombia University New York.

Addressing the inaugural meeting of the Berri Chapter of the Hydrological Society to a packed auditorium Professor Simpson spoke on the El Niño effect and its influence on the flows in the Murray Basin. Knowledge of The El Niño ocean temperature effect and the Southern Oscillation Index have been around for more than seventy years since some pioneering work was undertaken by Mr Walker, a British scientist in India. Recent research efforts have improved the predictive capability of climate models. The Murray Basin is clearly demonstrated to be influenced and it is now practical to make reasonable predictions up to one year ahead of the likelihood of flood or drought conditions. Clearly this can lead to improved decision making for river management, water allocations or cropping decisions, especially in the wetter parts of the catchment. In the Lower Murray, where flows are moderated by regulation, it may be possible to improve the management of flows for improved ecological outcomes.

Weather cycles appear to follow four year cycles. The current indications are that we can expect a wetter than average cycle for the coming year.

Professor Simpson is looking for other applications for the knowledge of the effects of El Niño. "If you could predict next year's rainfall with better odds than at the Casino, what would you do with that information?" the professor asked.

Professor Simpson also praised an Australian software package called 'Australia the Rainman" which can be used at a local level to help use this longer term predictive capacity. Prof Simpson is currently undertaking research at the Centre of Groundwater Studies at the Waite Campus in Adelaide. Contact the CSIRO Centre of Groundwater Studies for further information.

River and floodplain ecology and management.

Tuesday 11 June at the Berri Hotel from 9:30 to 4:30 pm

This meeting is being organised by the Wetlands Management Group of the Department of Environment and Natural Resources. You can lodge your intention to come by phoning DENR in Adelaide (08) 204 8742 or by phoning DENR in Berri on (085) 95 2218

Groundwater data base instituted on world wide web

A user contributed data base Urban Groundwater Database has been instituted at web site http://www.dwr.csiro.au/UGD/

You provide the data for your favourite city, and this will be formatted and stored permanently at this site in a form accessible to anyone. You can submit an entry directly into the database via the web site, or send it in by email, fax or post. The database is an initiative of the International Association of Hydrogeologists (IAH) Urban Groundwater Commission and is managed by

Dr Claus Otto
CSIRO Division of Water Resources
Floreat Park Laboratory
Private Bag
PO WEMBLEY WA 6014
email: claus@per.dwr.csiro.au
tel: (09) 387 0367
fax: (09) 387 8211
hhtp://www.per.dwr.csiro.au

(from IAH Newsletter 13 1, February 1996

WATERFALL GULLY WETLANDS STUDENT PROJECT

Bart van der Wel

Review of Total catchment management plan and proposed First Creek wetland, City of Burnside (1995).

Waterfall Gully (First Creek) has been the subject of an investigation to create wetlands by 16 students from the University of Adelaide's Department of Civil and Environmental Engineering. Council engineers selected a wetland site at the northern end of Waterfall Gully Road from an overview by the students of existing public open space in the Burnside Council area. Three ponds in series was the system analysed.

The proposed wetland site captures an area of 13 km^2 predominantly a regrowth woodland which is now Cleland Conservation Park. Immediately upstream of the proposed wetland, ribbon development of housing immediately adjacent to the creek is served by septic tanks. One tributary has a closed rubbish dump.

The aim of a wetland was to:

* improve water quality downstream and into the River Torrens;
* provide flood attenuation to enhance the capacity of the existing waterway throttled by exotic vegetation and culverts;
* improve amenity through removal of exotic vegetation and attract native birds; and
* implement water reuse through aquifer recharge.

The study estimated peak runoff using RORB and the flow from the DENR flow gauging station, which found that the design would require modification to attenuate flows. Grab samples for selected water quality parameters were analysed weekly for two months. The conclusion made that septic tank seepage one of the more significant forms of pollution based on the higher than expected concentration of phosphorus. A makeshift trash rack was also installed and the nature of the coarse debris analysed. Suggestions were given on suitable replacement vegetation from an environmental view point and to enhance water quality, and a concept structural design prepared.

The results are being implemented by the City of Burnside, which has allocated funds subject to a contribution from the River Torrens Catchment Management Board.

For the first time in South Australia, a Waterwatch program has been established specifically to identify pollution causes and establish baseline data, rather than as an educational exercise. Sampling and analysis is being carried out by residents of Waterfall Gully Road with dedicated equipment purchased by the Council. Sampling will include transects along the creek of macro-invertebrates and soluble phosphorus to correlate river health with urbanisation.

Students who prepared the report were:

TCM:	Design	Hydrology
Martin J	Lange J	Dolling T
Semple Z	Phillips S	Jacobi D
Cobiac L	Hall R	Passfield G
Headon C	Benham T	Vivian N

Water quality	Environment
Webber A	Hewitt J
French R	Murphy S
Penfold D	Tanner C
Kalisch B	Desmier R

$50 Hydsoc Prize for Best Contribution $50

The Hydrological Society has offered a $50 prize for the best article submitted. To help the editors decide, please register your vote with David Walker by 31 July 1996.

Tel 303 4319
Fax 303 4359
email dwalker@civeng.adelaide.edu.au

MEMBERSHIP OF CONSERVATION COUNCIL OF SOUTH AUSTRALIA

Bart van der Wel

The Society is considering membership of the Conservation Council, an umbrella organisation of Conservation groups aimed at protecting the environment and society. It includes a diverse range of groups from National Trust (building conservation), Civic Trust (urban design), 4Wheel Drive Club, Adelaide Bushwalkers to Friends of the Earth and Greenpeace. The Council recognises the extreme importance of water to the environment.

The cost to the Hydrological Society will be about $200 for which we will have representation on the committee of the Conservation Council with the ability to put our views on the environment and receive a quarterly newsletter.

The committee would like to hear from you on whether we should join. Register your opinion with Chris Purton at BC Tonkin

Tel 223 5583
Fax 223 5237

Patawalonga Environmental Impact Statement

A supplement to the Patawalonga Environmental Impact Statement is now out for public comment by 22 June, 1996. The supplement indicates the impact of 3 options for treatment or diversion of catchment flows and the construction of groynes for a ferry terminal at the mouth and a boat harbour at West Beach. The economics of the proposals appear to have been omitted. Copies of the supplement can be obtained for $20 from the State Information Centre, 77 Grenfell St., Adelaide.

Water Efficiency and Cleaner Production in a Large Wine Producer

1995 Ian Laing Prize Winner, Simon Clarke

The Ian Laing prize is awarded annually by the Hydrological Society to the best student presentation. Ian Laing was an exemplary graduate of the University of Adelaide in Civil Engineering and spent all his working life with the Engineering and Water Supply Department mostly in Water Resources before his untimely death. He was an active member (including chairman) of the Hydrological Society.

I graduated from the University of Adelaide with a degree in Civil and Environmental Engineering. The Civil and Environmental Engineering course is a new degree providing a mix of traditional civil engineering and environmental engineering. This course also develops skills in law, economics, ecology and geology.

Many of the lecturers in the department have expertise in hydrology, water quality monitoring, coastal engineering, wetlands and water distribution system optimisation, planning and economics. This expertise is often passed on in the lecture series provided. The subjects I studied dealt with issues in water resources planning and management, water quality including water treatment and wastewater treatment. Other subjects included waste management, environmental law, economics and geology, and ecology.

Many of the skills acquired throughout the course were needed for a final year honours research project. The research project was set up and done by another student and myself. We selected the topic and approached a winemaking company, Mildara Blass for sponsorship, which it provided. The topic was "Development of efficient water management and reuse strategies for Mildara Blass Wineries". The emphasis of this project was firstly to find ways of reducing water consumption in the winemaking process. Secondly the emphasis was on cleaner production techniques in order to improve effluent quality and lower effluent volumes. This investigation was carried out at two Barossa Valley wineries, Wolf Blass (Bilyara) and Krondorf.

The project looked at the newly created legislative requirements for winery effluent management. Auditing and investigation of the winemaking process was done and has been set up on an ongoing basis. As a result, an investigation into stormwater management, and possible effluent, minimisation, reuse, recycling and treatment was performed. A logical and analytical investigation into the winemaking process was taken in order find solutions.

The investigation found that improvements could be made in several areas of winery operation. This includes preventing stormwater from entering the effluent streams, and then its storage and reuse elsewhere in the winemaking process. This requires modifying drainage systems both physically, and in their operation. If solids such as lees, marc, and diatomaceous earth are prevented from entering the effluent streams, significant improvements in solids loadings and BOD, are anticipated. As a result the water may be suitable for other processes, or more easily treated. More water efficient cleaning and sanitation systems were also investigated. This area of water usage accounts for over 50% of water usage in wine production thus any improvements made will improve any effluent that is produced. The areas of steam cleaning, concurrent washing systems and the use of 'polyshot' cleaning systems show promise in this area.

The investigation showed that the traditional approach to winery effluent management had been upon end of pipe treatment. The research project aimed to provide a preventative approach where the impact of the effluent was minimised or prevented. In order to achieve this a formalised procedure for implementing an auditing and cleaner production methodology was developed for the wine industry. This type of document did not previously exist specifically for the wine industry.

The project has highlighted several areas where further work may be required. Firstly it was found that no investigation into the use of wetland systems to treat winery effluent has been performed. At present most disposal is onto woodlots or irrigation. The disadvantage of this method is that the water is not recovered and the saline water may be contributing to ground water contamination, or soil degradation. Secondly much of the Barossa's water supply is groundwater. The use of aquifer recharge has not been explored as an option for water storage (either stormwater or polished effluent). A primary environmental concern of winery effluent is its high salinity. This salinity is a result of the already saline water which is often used for production and the use of caustic soda for sanitation in the winemaking process which further increases the salinity. Due the conservative nature of the salts their impact upon the environment may become significant.

This project is of importance to environmental management as the availability of water in the Barossa Valley is restricted. This project may finds ways of providing additional water which can be used for production and irrigation of vines. There is a significant opportunity cost associated with using this water for wine production and then simply disposing of the effluent rather than treating it as a resource. This cost is a result of the industry being unable to expand due to the restriction of water available for irrigation and production.

The expansion of the wine industry would provide significant economic benefits. The industry is aiming to increase production (and exports) by 50% in the next 15 years. In order for this to be achieved, the effective management of water as a resource and effluent management systems need to be significantly improved.

LETTER FROM CHILE - *Impressions of a long thin country*

Peter Smith

It is about 18 months since I cut the umbilical cord and departed from Mines and Energy SA and Australia. As the title suggests, with profound apologies to Alistair Cook, this note purports to give my view of Chile as a soft-core gringo (Español for a foreigner of Anglo Saxon lineage).

Chile is a land of contrasts, be it culture, politics, geography or economics. Culturally, it ranges from height of sophistication, with well stocked art galleries, museums and a world class opera house in Santiago, to the most basic indigenous culture and subsistence living (some parallels to Australia!).

Politically, Chile appears to an outsider, particularly an Australian, much more polarised than one would experience in the "developed world". The main topics of conversation when Chileans get together are politics and money. Contrast this with, say, the Australian experience where politics can be a taboo subject in the front bar!

Chile is slowly emerging as a more or less democratic country, although the behind the scenes influence of the military remains strong.

For a South American country, it is quite Western, particularly Santiago, which has about half the country's population. As well as the strong Spanish influence, I was surprised by the extent of British and German presence in Chile. The British were responsible for much of the early mining development during the late 19th century (nitrate, copper and gold), particularly in the north. They also trained the Chilean navy.

On the other hand, the Germans settled further south and became involved in commerce and agricultural development. The Germans trained the Chilean army - evidence the uniform and goose-stepping military parades.

Geographically, Chile runs the full gamut of terrain and climate from the hot aridity of the near coastal Atacama Desert and Alti-Plano at about 4000 m in the north, to glaciers, fjords and volcanoes in the south. In the central regions is a moderately developed "coastal plain" which supports a wide range of agricultural and horticultural development.

Economically, Chile remains dependent on copper exports, although the trend to democratisation is paralleled with the development of a more diverse economy. The extent to which the country depends on copper production is highlighted by the fact that the military has written into the constitution the direct transfer of funds to it from the state owned copper producer, Codelco.

Chile remains, however, almost totally a primary producer; minerals, forest, agricultural and fish products dominate its exports. There is, like Australia, a desire to become a "smarter country" with a greater economic reliance on secondary and tertiary industry, for example, software production. Its highly developed telecommunications system (one Alan Bond was once involved) is a prime example of this trend.

What's it like to live in Santiago? In a word: expensive! Although having been away from Australia for about 18 months, I would say that living here is about 30% more expensive than in Australia, not helped by the fall of the US dollar against the peso.

Santiago has a world class smog problem with the thousands of bright yellow buses getting much of the blame. However, Santiago's public transport system is exceptionally good with the aforementioned buses (drivers variously described as "savages" or "animals"), a Metro (better and cleaner than its clone in Paris) and collectivos (collective taxis).

Food is generally disappointing and eating out is expensive for the quality. The raw materials are of high quality, but there is not much inspiration in their use. Santiago has only one Indian restaurant for example!

Beer and wine (in contrast to food) are very acceptable both in quality and price. A 1L bottle of beer (Español: cerveza) costs about AUD 1.60, while a very drinkable red would set you back between $ 5-6.

Santiago in particular, and Chile in general, boasts very attractive women. I don't go for the men much - far too macho for a quiet, sensitive person such as myself.

What's it like working in the groundwater field in Chile? The primary focus of the company I work for is consulting on water issues, not unexpected to the mining industry. As much of the mining development is in the north, the work has been concentrated in the Atacama (east of Antofagasta - consult your atlas) or the Alti-Plano east of Iquique in the I and II Regions of Chile.

The job in the Alti-Plano (4000m +) was adjacent to Steve Barnett's work area of 1993 and consisted of water supply augmentation and well rehabilitation in Salar de Michincha. The mine involved extracting copper using the heap leach method and producing fine copper by electro-winning. The area is subjected to the "Bolivian Winter" between December and February - a unique climatic event in which you get hot and sunburned to about noon and snowed on in the afternoon! The associated electrical storms are awe inspiring.

Most large scale water supply developments in the arid northern areas are in, or adjacent to, salars. Salars are generally located between 2500 m and 4000 m and are local or sub-regional groundwater sinks. Aquifers vary lithologically from unconsolidated alluvial/colluvial deposits to extremely hard, fractured ignimbrite. Yields from individual wells vary from a few litres per second to over 100 L/s. The high yields are generally from well fractured ignimbrites. Water quality can be potable but is acceptable for mineral processing. Relatively rapid encrustration of well screens requires regular rehabilitation of re-development of production wells. Most wells are gravel packed, which contrasts with general Australian practice.

More recently, I have managed a wellfield expansion project east of Antofagasta. This involved the drilling of about 40 large diameter production wells with depths ranging from 100 m to 300 m. Average yield per well is about 25 L/s. The aquifer is in alluvial/colluvial Tertiary to Recent sediments. In addition to the production wells, about 40 exploration/observation wells were constructed using a combination of air reverse (with or without flooded annulus for hole stability), conventional mud rotary and diamond coring for stratigraphic control. At its height, the project used 13 machines for drilling and test pump installation.

Currently (September 1995), we are working on a wellfield development (20 x 16" wells to produce a total of 1000 L/s) at about 3000 m and 150 km east of the previous project area, close to the border with Argentinia. One of the delights of the job is driving through a mine field on one of the major passes linking Chile with Argentina!

In addition to production well construction, there is a need to better understand the hydrodynamics of the basin. One of the tools being considered is the use of environmental isotopes. I am hopeful that South Australian expertise will be used.

For further information on Chile, potential job prospects, etc, I can be contacted at:

Water Management Consultants (Chile Ltda)
Enrique Foster Sur 76
Las Condes, Santiago, CHILE

Tel +55 2 246 3480
fax +55 2 246 3518

Peter Smith

Wild Rivers

The Commonwealth Government has initiated a project to define and identify wild rivers (those that have suffered little disturbance) in South Australia. Rivers in the Flinders Ranges and Kangaroo Island head the list, and tributaries to Lake Eyre to a lesser degree.

For further information contact Wild Rivers Conservation Management Guidelines c/- Director Wilderness and Wild Rivers Unit
Australian Heritage Commission
GPO Box 1567
CANBERRA ACT 2601
Tel (06) 217 2111 Fax (06) 217 2000
E-mail wrivers@ahc.erin.gov.au

Deep Conservation Park draft management plan

Bart van der Wel

The National Parks and Wildlife Service has released a draft management plan for public comment as it is required to do under its Act.

The park is dissected by numerous stream, some permanent, which define its vegetation characteristics and provide scenic beauty. Some permanent waterholes and a waterfall provide a relief for bushwalkers along the long distance Heysen Trail. Some of the streams originate in grazing land and forest outside the park, and excessive algal growths indicate pollution.

Despite the importance of the hydrology to the Park, no management actions are indicated to monitor and improve water quality, or to research the importance of environmental flows and the flow regime to the maintenance of the conservation, scenic and amenity values.

Closing date for submissions 14 June 1996.

For further information contact District Ranger
Victor Harbour Office
Department of Environment and Natural Resources
PO Box 721
VICTOR HARBOUR SA 5211

City of Adelaide Environmental management plan Local Agenda 21

The City of Adelaide has released a draft Environmental Management Plan for comment,

The plan includes proposed actions on improving water resources management within the city, including water harnessing, water pollution control and demand management. A list of sustainability indicators is given by which progress achieving sustainable development can be gauged.

Closing date for submissions 5.00 pm Wednesday 21 June 1996
For further information contact the Corporation of the City of Adelaide (Ms Susie Herzberg) (08) 203 7519.

Patawalonga Catchment Management Plan

The revised initial catchment plan has been revised to incorporate public comments. The next version is in progress and a community liaison group has been established through the Australian Conservation Foundation.
Contact BC Tonkin and Associates (Hugh Orr).

Torrens Catchment Management Plan

The initial catchment plan has been revised. The next version is in preparation through a series of public meetings. Contact Hasell (Irene Jones) (08) 203 5222.

River Torrens Lake strategic study

The City of Adelaide has commissioned an investigation into the River Torrens lake. Public consultation has occurred and a report is due in May 1996.
Contact Rust PPK (Andrew Telfer)

Glenelg River under threat

Increased environmental flows for the Glenelg River are called for by the Glenelg River Environment Group (GREG).

The Glenelg River catchment originates south of the Grampians. As always, South Australia is at the bottom end of the catchment, although the mouth is in Victoria, at Nelson.

Rocklands Dam was constructed on the Glenelg River in the early 1950s to divert water to the Wimmera. Although a trickle flow was supposed to be guaranteed in the Glenelg River for riparian users, even this has been diverted in times of stress. On average, over 70% of the Glenelg River is diverted.

According to a draft submission prepared by GREG, lack of flushing flows has resulted in increasing sedimentation, silting of the mouth and possibly increased salinity. The sediment is moving as a slug down the river, with implications for navigability in the tidal reaches which are the South Australian component. A barrier at the mouth has resulted in decline of numbers of eels, which require access to estuarine conditions during their breeding cycle. A barrier could also cause inundation during flooding of some shacks. The lack of trickle flows has resulted in a loss of species diversity and numbers.

With further diversions to the Wimmera from the Goulburn River through a proposed pipeline system, GREG sees opportunities for partial restoration of the flow regime in the Glenelg River. GREG sees an obstacle to integrated catchment management is the lack of representation from the Glenelg River catchment on the Wimmera Mallee Water Board. Furthermore, diversions are controlled by the Wimmera River Catchment Coordinating Committee without reference to the catchments from which the water is diverted.

It is probable that the South Australian Government is also not consulted. This river could be managed by an inter-governmental commission similar to the Murray Darling, given the impacts on South Australia of ecological change adjacent to the Glenelg River National, Park and the movement of sediment slugs downstream.

For further information contact the Glenelg River Environment Group, PO Box 860, HAMILTON VIC 3300, tel (055) 725150, fax (055) 712044 (Mr Ken McLeod, Business Centre Manager, Hamilton Region 2000 Inc).

Irrigation and Garden Watering - can we afford it?

Tony Thomson
Irrigation Engineer, Lenswood Centre, PISA

If you paid an additional one cent for each kilolitre you use how much would this cost you? Most irrigators and home gardeners do not know how much water they are using or how much they should be using.

Have you ever seen water flowing on the road at the end of an irrigated paddock? At least one creek in the Mount Lofty Ranges flows more in summer than in winter due to drainage from irrigated paddocks.

South Australian irrigators can get higher returns through improved irrigation practices, and be more environmentally friendly in the process. By changing their irrigation practices, farmers and other irrigators can make huge improvements to their water use, leading to a better use of energy, fertiliser and other chemicals.

The main attraction of improved irrigation methods is the opportunity for increased yield quality and quantity and decreased salinity problems.

Data collected by Primary Industries South Australia officers and growers shows that many irrigators need to change their irrigation practices - and that there are many advantages to be gained.

Woodside potato farmer Keith Gale, Nairne sprouts growers A.E. Cranwell & Sons and Willunga almond grower Leath Hunt have already reported significant increases in both yield quantity and yield quality. The trio believe the time and money invested in improving irrigation system performance and improving irrigation management practices was well spent.

Irrigators are encouraged to undertake "Six steps to improve irrigation."

In steps 1 and 2, irrigators work as a group to keep simple records and compare their own data. They discover that their irrigation practices and application amounts differ dramatically.

In step 3 irrigators participate in a series of irrigation workshops where basic irrigation principles are discussed and compared with their own practices.

In step 4 the growers use what they have learned in previous steps to evaluate and improve their irrigation systems and their irrigation management.

Only after improving irrigation systems and applying good irrigation management are further improvements available from installing monitoring equipment (step 5) and using the exciting technological advances in soil moisture, sap-flow and other equipment.

In step 6 growers use the monitored data to optimise their returns per kilolitre of irrigation water.

The diagrams show the wide variation in irrigation practices for two crops in the Southern Vales. In 1993-4 the irrigation depth applied to grapevines varied from zero to 800mm. Only one quarter of the grapes received the target irrigation depth, the remaining area received either too little water or too much water. Some grapes received almost 7 times the target amount.

Most of the almonds were irrigated with less than half of the irrigation requirement. Less than 10ha of almonds received the target amount.

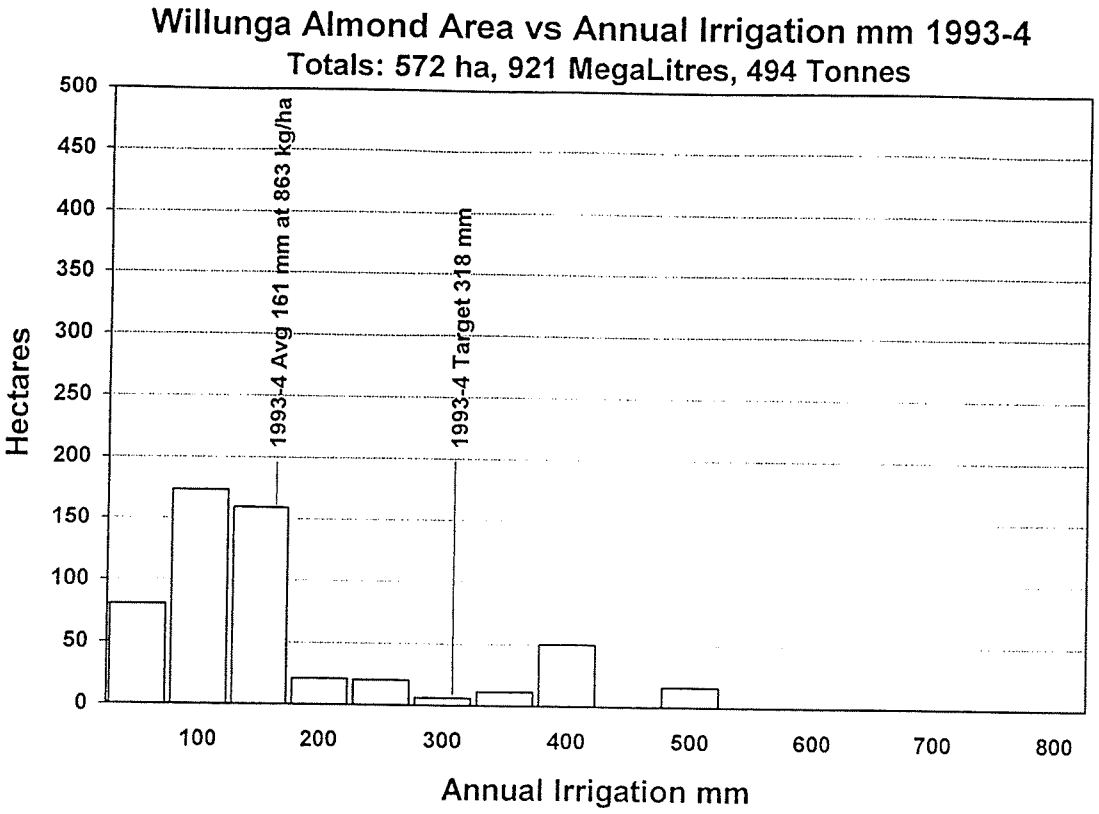
The diagrams highlight the huge differences in the annual irrigation depth applied - and that some growers need to halve their annual irrigation application, while others need to double their annual application.

Growers have collected data showing similar results for winegrapes in the Barossa, pasture in the South East and potatoes in the Adelaide Hills. These groups of growers are working with PISA through the sequence of "Six steps to improve irrigation practices."

For the same crop in the same location collected data also shows a wide variation in the depth applied per irrigation and in the number of days between irrigations. The data shows that large volumes of irrigation water are wasted to drainage below the plant roots.

The PISA Property Management Planning program coordinated by Susan Sweeney includes an Irrigation Field Day, where participants measure the performance of an irrigation system and a workshop on Irrigation Scheduling and soil moisture devices. Participants report enjoying these sessions and that they use their new skills to improve their own irrigation practices.

Irrigation publications and information on Property Management Planning courses are available from Lenswood Centre PISA on 3898800.


Willunga Almond Area vs Annual Irrigation mm 1993-4
Totals: 572 ha, 921 MegaLitres, 494 Tonnes
Hectares
Annual Irrigation mm
1993-4 Avg 161 mm at 863 kg/ha
1993-4 Target 318 mm
0
50
100
150
200
250
300
350
400
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100
200
300
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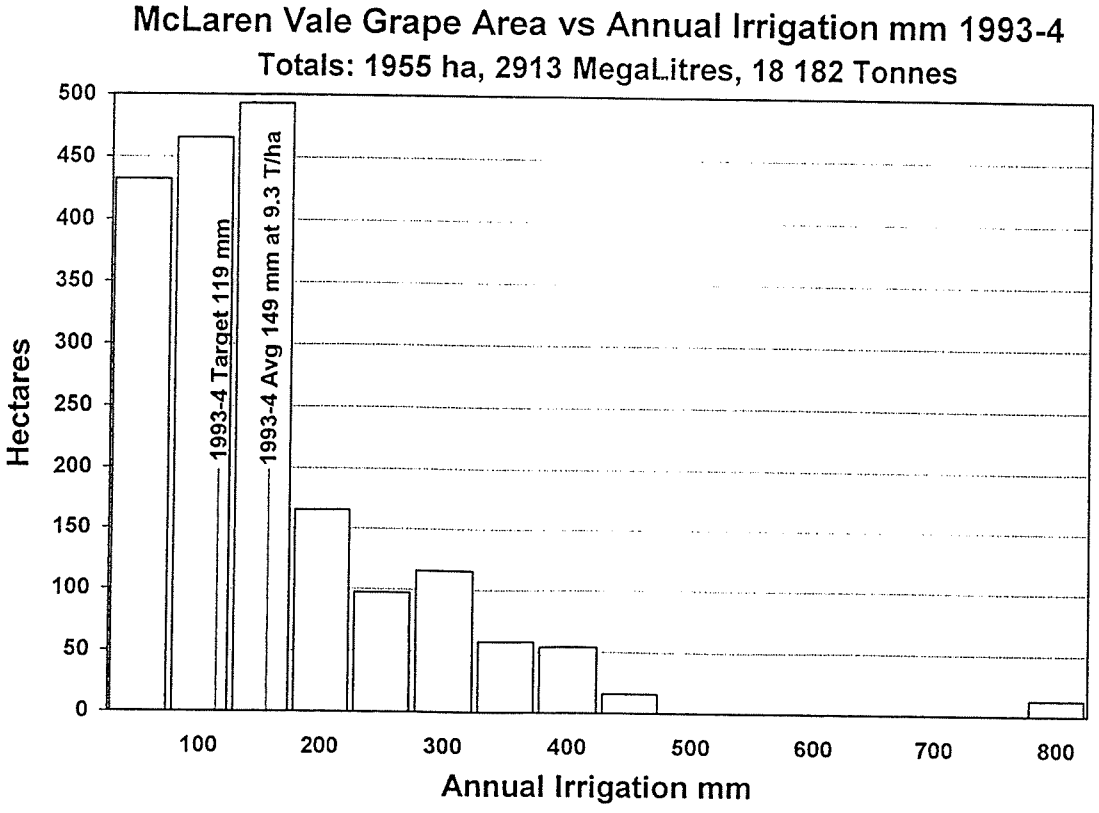
500
600
700
800


McLaren Vale Grape Area vs Annual Irrigation mm 1993-4
Totals: 1955 ha, 2913 MegaLitres, 18 182 Tonnes
Hectares
Annual Irrigation mm
1993-4 Target 119 mm
1993-4 Avg 149 mm at 9.3 T/ha
0
50
100
150
200
250
300
350
400
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100
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300
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500
600
700
800

A Proposal For a RRR (Rainfall- Runoff - Routing) Model

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Background

The runoff routing models in use in Australia today have their origins in the 1960s with such models as the Laurenson Runoff Routing Model. The basis of these models is that direct runoff only is considered and that the storage within the catchment can be represented by a series of concentrated storages along the major watercourses of the catchment. This simplified representation has been used for the past 25 years, with minor variations regarding the allocation of storage within the watercourses.

If the investigations into the parameters are examined it becomes clear that the reason for the differences in lag between catchments cannot be explained consistently by physical variables. As well as this, significant variation or noise occurs within individual catchments. Some, but not all, of this noise may be explained by the inadequate representation of input parameters such as rainfall.

In the case of the storage parameters of the RORB model, if the strong relationship with catchment area implicit in the model is neglected, the only other consistent relationship is with average annual rainfall for some parts of Australia.

If the model is reflecting reality it would be expected that better relationships would have been found. This brings into question the basic assumption of current runoff routing models that the total catchment storage may be modelled by the catchment channel system.

It is proposed that runoff processes play an important part in catchment lag. This variation in catchment process is creating the variability in lag which cannot be explained in current models. A new model is proposed that takes into account runoff processes as well as the storage effects of the watercourses. Only by the adoption of such a model will flood prediction practice move forward from the 1960s.

The Evidence of Variable Catchment Lag - The Lidsdale Catchments

In 1963 the University of New South Wales established a group of experimental catchments within the Lidsdale State Forest 12 km west of Lithgow in New South Wales. The group comprised eleven small forested catchments and the original purpose was to study the differences in water yield between catchments planted with pine forest for commercial purposes and catchments remaining under natural eucalypt forest.

The flood response of the individual catchments was examined. The method chosen was to derive response functions (unit hydrographs) for a number of flood events on the catchments. It was found that four categories of flood response could be found for the catchments. The categories were named:

- Large non-linear: Unitgraphs with unusually large peaks.
- Partial area: Unitgraphs having a similar shape to the above, but having lower peaks. These were interpreted as events where only a small sub-section of the catchment was contributing to runoff.
- Small non-linear: These were unitgraphs with very small peaks, and came from very small floods.
- Normal: The rest of the unitgraphs could be identified as a consistent set, which was termed normal.

The differences in flood response were related to the three distinct physical processes by which runoff is generated, that is Hortonian runoff, saturated overland flow and throughflow (a type of sub-surface flow).

Inspection of individual events indicated that antecedent wetness of the catchment could significantly modify the type of event resulting from a particular rainfall pattern

The Common Unitgraph

Tom Chapman has developed a technique for estimating a common unitgraph and event input hyetographs for a set of surface runoff events, without using rainfall data. However, it has been found that the common unitgraphs obtained in this way from streamflow data typically have an earlier and higher peak and shorter duration than average unitgraphs derived by conventional methods using rainfall and loss data. The calculated input hyetographs from the technique continue after rainfall has ceased, and they have peaks which occur later than the corresponding rainfall peaks. It was found that these problems could be resolved by the insertion of a non-linear storage between the usual rainfall loss algorithm and the common unitgraph. The final prediction of runoff from rainfall from this approach was found to be at least as good as those obtained by conventional methods and extend over a wider range of flows.

It was postulated that the rainfall loss and non-linear store model the processes of infiltration and overland flow, while the common unitgraph routes the stream flow to the outlet.

This splitting of "out of channel" processes and channel routing, assuming linear storage supports the runoff process dependence of lag. The linear channel routing is supported by the findings of constant flow times for most events found by Pilgrim. The common unitgraph represents a minimum catchment response time. If the response time for the overland flow non-linear storage is also minimised, as occurs in major events with a non-linear storage outside the channels, then the catchment response would appear to become linear at high flows.

The Proposed Model

The consideration of the above view that a catchment does not have a single lag leads to the proposal for a better model structure for a runoff routing model that mimics the actual catchment behaviour.

The model has to have separate channel storage and hillside or process storage. This represents a major change to existing runoff routing models that assume that only surface runoff is being modelled, and that the total storage within the catchment can be represented by a series of storages along the watercourses.

The model type is therefore worthy of recognition as a separate class of model, to be named in this paper the RRR (or Rainfall Runoff Routing) model. The model is so named because like rainfall runoff models it models hydrological processes, and like runoff routing models these processes are represented by a series of concentrated storages.

The hillside storage must be able to be split to allow for the different contributions from the different processes occurring. Since each process on the hillside is assumed to enter the channel by a separate path it is allowable to have non-linear storage in the hillside part of the model.

The channel storage is likely to be linear for most flows as evidenced by Pilgrim's travel time work, and the finding of a common unitgraph by Chapman.

A model structure is proposed as follows,

- The model has ten equal channel reaches of length d/10, where d is the longest flow path length in the catchment (km). It is assumed that the area contributing to each reach is also equal, i.e. (total catchment area/10).
- channel storage for each channel reach is modelled as a linear storage of the form $S = 3\,600\,k\,Q$.
- Contributions from any number of separate hydrological processes can be added at the downstream end of each channel reach before routing through the channel storage.
- Each of these processes is modelled as per Laurenson's Runoff Routing Model , as used in the RAFTS model i.e. with ten equal sub-catchments each with a storage $S = 3\,600\,k_p Q^m$, k_p being a lag related to runoff process. The total area of each process model is the total catchment area/10, so that the area of each sub-catchment is the total catchment area/100.
- Each of the hydrological processes has an initial and continuing loss associated with it.

The use of ten storages for both the process and channel storages follows the Laurenson Runoff Routing Model, and provides for differing elements of rainfall excess to pass through different amounts of storage. The catchment is not however delineated with equal travel times, but with equal areas, as per the RAFTS model. No investigation has been carried out into the sensitivity to the number of sub-catchments.

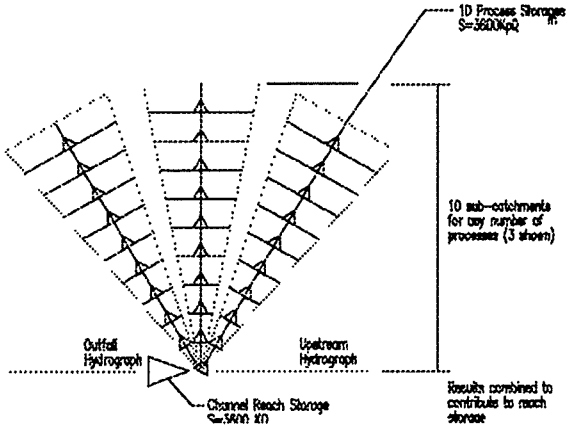

Figure 1 Structure of the RRR Model

Although the model may initially look complicated with 100 sub-catchments it is in effect simple as all sub-catchments are the same size, and storage parameters and losses need be input only once for each process modelled. The model can be easily set up using the RAFTS-XP interface.

Fitting the Model - Aldgate Creek

The model was initially tested on the Aldgate Creek catchment (AW503509) for events that had been previously modelled by RORB. Aldgate Creek is located in the Mount Lofty ranges, has a catchment area of 7.8km^2 and an average annual rainfall of 1000mm. The model was set up as above and calibrated as follows for an event in September 1973. The event was selected due to the inability of the RORB model to model the second peak of the gauged hydrograph.

Modelling was initially carried out without the baseflow contribution (baseflow separation was carried out in the previous investigation).

It was assumed that flow was occurring from one process alone. The initial loss was then set to model the start of rise of the hydrograph. A continuing loss was set and the value of k for the channel and m and k_p for the this first process varied to match the outflow hydrograph for the

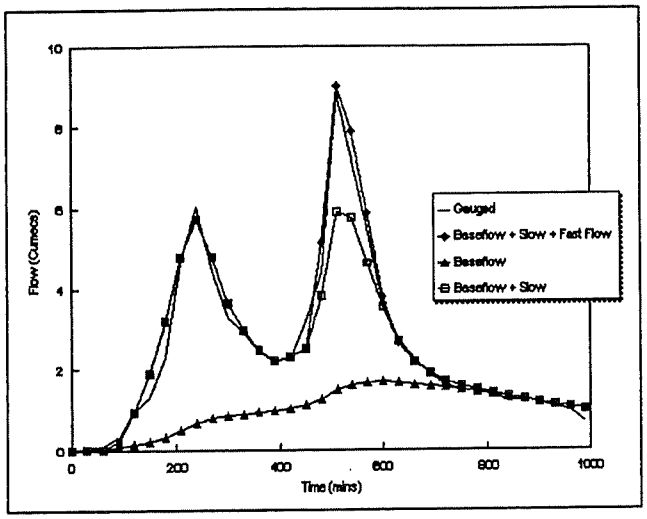

Figure 2 Aldgate Creek RRR Model Fit, September 1973

commencement of the runoff event. A value of m = 0.8 was used, in line with normal practice for ungauged catchments. It was found that the main effect of k_p was to vary the shape of the hydrograph, and k provided a translation. It was thus possible to match the start of the event, but as the event progressed in time there was obviously another contribution to runoff.

The next contribution was assumed to be from another process. Thus a second process storage was introduced, leaving the contribution from the first process as calibrated. The initial and continuing loss were set to model the start of the second contribution and the total volume of the contribution. It was found that k_p for the second process needed to be set to a very small value (RAFTS allows 0.001) to model the contribution.

The full hydrograph was then used, including baseflow. All other parameters were set as above, and k_p and initial and continuing loss for the baseflow contribution were varied to match the total hydrograph.

A proportional continuing loss was assumed throughout.

Several important findings came out of the calibration:

- There were three distinct process related lags apparent, and for the purposes of discussion these will be named slow, fast and baseflow contributions corresponding to the sequence of processes described above.
- The baseflow contribution shape was as would be expected if a baseflow separation method had been used.
- The contribution of the fast runoff did not require any further lag than would be expected from the channel storage. This contribution was linear.
- The slow contribution is the contribution that would normally be modelled with the calibration of a runoff routing model.

Figure 2 shows the fit obtained using the RRR model for the September 1973 event. The best fit that could be obtained using the RORB model approximated that of the base flow plus slow flow contribution, without matching the second peak of the hydrograph. Table I lists the fitted parameters. The channel lag parameter k was 0.05 hours.

Contribution	IL (mm)	CL (prop.)	k_p
Base	0.0	0.80	0.9
Slow	3.0	0.78	0.1
Fast	42	0.82	0.0

Table I Aldgate Creek RRR Model Fitted Parameters, September 1973.

Fitting the Model - Kanyaka Creek

Kanyaka Creek (AW509503) is located in the Flinders Ranges in an area having an annual rainfall of approximately 300mm. It has a catchment area of 180km^2. A RORB fit run had been carried out for the storm event of March 1989. The RORB model had difficulty matching the start of the rise of the hydrograph and the peak. A RRR model fitted as above gave a much better fit, indicating contribution from both slow and fast flow. No base flow was apparent in the gauged hydrograph.

Table II summarises the fitted parameters. The channel lag parameter k was 0.25 hours. Figure 3 shows the fit obtained.

Contribution	IL (mm)	CL (prop.)	k_p
Base	-	-	-
Slow	32	0.85	0.9
Fast	105	0.80	0.0

Table II Kanyaka Creek RRR Fitted Parameters, March 1989.

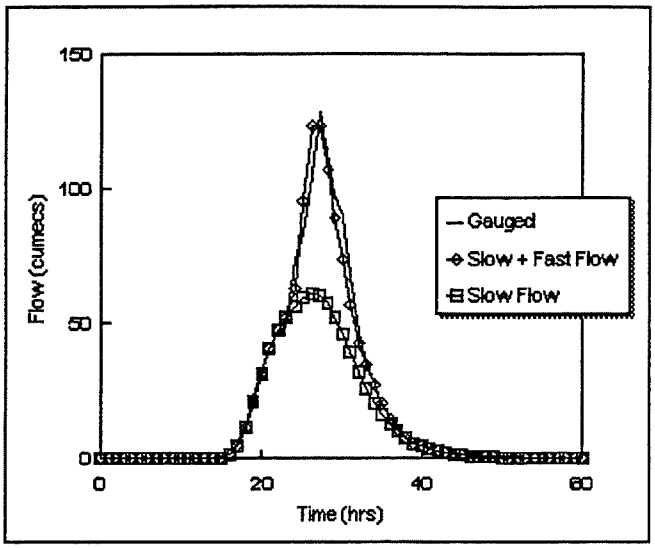

Figure 3 Kanyaka Creek RRR Model Fit, March 1989

Fitting the Model - Frederick St., Glenelg Catchment

The RRR model was fitted to an urban catchment at Glenelg, South Australia. A good fit was achieved without using a time shift that was required when fitting the RAFTS model to the catchment. This indicates that the model structure is a better representation of the catchment process than the RAFTS model.

Figure 4 shows both the fit obtained by the RAFTS model (without a time shift) and the RRR model.

Both the process and channel storage in this case were linear (i.e. m=1). The process lag k_p was 0.011 hours indicating a total storage delay time of 0.11 hours or 6.6 minutes. This is of the same order as the normal time of entry of the ILSAX model (5 mins).

The fitted channel lag k for each storage was 0.036 hours.

It can be concluded from the above description that the channel storage lag represents the total pipe plus gutter lag.

Expected Generalised parameters

Lag parameters

As the channel lag is linear it could be expected that for rural catchments the channel lag is highly correlated with the mainstream length of the catchment. Indeed for the purposes of the derivation of a generalised parameter, a further variable representing the characteristic flood wave velocity v_c could be introduced. This could be related to channel lag k as follows.

$$v_c = \frac{d}{(36\,k)} \qquad (1)$$

Where v_c is the channel characteristic flood wave velocity (m/sec)

d is the longest flow path length (km)

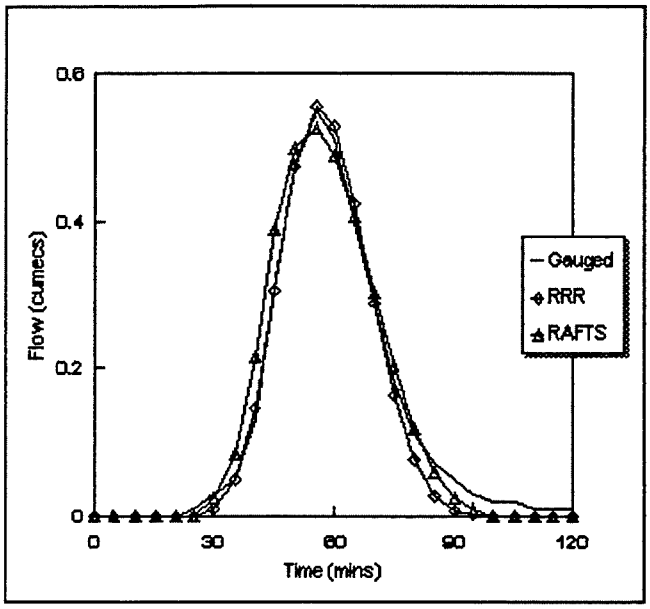

Figure 4 Frederick Street, Glenelg Catchment RRR Fit, October 1993

k is the channel storage lag parameter (hrs)

For the Aldgate Creek and Kanyaka Creek v_c is 2.5 m/sec and 3.0 m/sec respectively. Further work must be carried out on a range of catchments but it can be expected that v_c would be relatively stable with the greatest variation being with average annual rainfall, as channel sections become more efficient in arid areas.

Losses

It is expected that the losses for the processes will vary over time as the catchment conditions vary. Further work will have to be done in this area.

However, if losses can be related to catchment condition, for example by the catchment Antecedent Precipitation Index then the model could be extended to run as a full rainfall - runoff model

A complicating factor may be that both losses and storage parameters may vary over time depending on the proportion of the catchment contributing.

Discussion

It is remarkable how the simple model structure of the RRR model can improve the level of fit observed in the events examined so far compared with the normal runoff routing model. As such it represents a model structure that should supersede the current runoff routing models.

One great advantage of the RRR model is that it directly models base flow and thus no base flow separation, with the attendant uncertainty has to be carried out. When design flows are calculated the base flow contribution can

be incorporated like any other contribution, instead of as an arbitrary allowance.

However if baseflow is occurring at the time modelling commences the model would have to be "run-in" with prior rainfall data to produce the correct baseflow.

The model will also give a better representation of the catchment response during extreme events when it can be expected that the fast flow contribution will become dominant. In extreme events catchments will appear to be giving a more linear response with a lag that is dependent on the characteristic flood wave velocity v_c of the channel. This velocity can be obtained by fitting more frequent events on the catchment. The adoption of the RRR model will therefore change the way in which extreme events are predicted.

With the investigation of how the losses for each process vary it is possible that the RRR model can be extended to cover the time steps usually associated with rainfall runoff models. In effect the process sub-catchments form the storages associated with the normal rainfall runoff model, with the losses representing the exchange of water between the storages. Further work needs to be done to explore this concept.

Conclusions

It is clear that catchment lag is related to hydrological processes that are occurring in the catchment.

A new model has been proposed that recognises this and promises to greatly improve the modelling of storm runoff events on catchments. The model represents a new class of model lying between the traditional runoff routing models and the rainfall runoff models.

It can be expected that the derivation of generalised values for the parameters of the model will be more successful than those for the current runoff routing models. Less noise and variation can be expected because the model structure is a better representation of what is actually occurring on the catchments. However the RRR model has the limitation that rainfall is assumed uniform across the catchment. For this reason it is intended as part of further work to expand the model structure such that rainfall and catchment variability can be modelled.

1995/1996 EXECUTIVE COMMITTEE OF THE HYDROLOGICAL SOCIETY OF SOUTH AUSTRALIA

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Auckland, Anwen	records secretary	274 7539		373 3269	
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Read, Kim	returning officer	223 5583		223 5237	

HYDSOC SEMINARS

Note some times and speakers have changed from previous publication. All seminars are at the Charles Hawker Auditorium, Waite Institute, Waite Road, Urrbrae, commencing at 5.30pm for 6.30 to 8.00 pm except as noted. The audience is invited to join the guest speaker at dinner afterwards.

Date	Subject	Speaker
Thursday 27 June 1996	Proposed revisions to the Water Resources Act	Megan Dyson, Crown Solicitors Office
Thursday 22 August 1996	Catchment Management, ANNUAL GENERAL MEETING	Alan Ockenden, Patawalonga and Torrens Catchment Management Boards
Thursday 17 October 1996	Neural Network Night	G Dandy, T Daniell, J Pannell, Faculty of Civil and Environmental Engineering, University of Adelaide
Thursday 5 December 1996	Coopers Brewery - water being put to good use	site visit

ENVIRONMENT AND NATURAL RESOURCES WATER RESOURCES GROUP 1996 TECHNICAL SEMINAR SERIES

In the South Australian Water Corporation "Learning Centre", Level 8, Australis House, 77 Grenfell Street, Adelaide 10.15 am for 10.30 am to 11.45 am.

19 June	'Get em Young' - The development of school curricula to include water issues	*Angela Colliver*
17 July	Impact of European settlement on erosion and sedimentation - Inman River catchment	*Jim Burston*
21 August	A catchment approach to water management - establishment and functions of catchment water management boards	*Jim Barratt and rep from Boards*
18 September	Integrated management of ground and surface waters - Clare	*David Cresswell*
16 October	Spatial technology for assessment of farm dam capacity	*Doug McMurray and Michelle Healey*
20 November	Water, a constraint to development? A regional development perspective	*Gordon McIntosh and representative from Regional Economic Development Organisation*
18 December	The case for a fundamental change to local water management - southern fringe area of metropolitan Adelaide	*Richard Clark*

UPCOMING CONFERENCES

Date	Title	Organiser	Location	Abstracts close	Contact
17-21 June 1996	Global energy and the water cycle. Second International Scientific Conference		Washington DC USA		tel +1 202 863 0012 fax +1 202 488 5364 e-mail gewex@cais.com
24-28 June 1996	Destructive water: natural disasters due to water: their abatement and control	IAHS and American Society of Civil Engineers	Anaheim, USA	closed	Prof F Nobilis tel +43 1 71100 6944 fax +43 1 71100 6851
1-5 July 1996	International Winter Environmental School	University of Queensland/AWWA/Institution of Chemical Engineers in Australia/CRC for Waste Management Control Ltd, Queensland node	Gold Coast, Queensland		M Burbridge, Department of Chemical Engineering, University of Queensland, Brisbane 4072 Email registration form from http://www.uq.edu.au.~e1mburri/iwes96.html forward to mikeb@cheque.uq.edu.au
6-10 July 1996	Groundwater discharge in the coastal zone, international symposium	Russian Academy of sciences and the Land-Ocean Intrecations in the coastla Zone core project of the IGBP	Moscow, Russia	by invitation	Dr Robert Buddemeier tel USA 913 864 3965 fax USA 913 864 5317 email Bob_Buddemeier@msmail.kgs.ukans.edu
9-12 July 1996	Water Africa '96-2nd Western Africa water and wastewater conference		Accra, Ghana	closed	African Conferences and Exhibitions Ltd tel +44 151 709 9192 fax +44 151 709 7801
15-19 July	Erosion and sediment yield: Global and regional perpectives international symposium	University of Exeter	Exeter, Britainn		Prof DE Walling tel +44 392 263345 fax + 44 392 263342
23-27 July 1996	Western Pacific geophysics meeting: hydrology program	American Geophysical Union	Brisbane QLD	closed	hhtp://earth.agu.org/kosmos/wpgm96ca.html#brisbane fax American Geophysical Union +1 202 328 0566
Autumn 1996	Hydrological cycle in complex landscapes	University of Bayreuth	Berlin, Germany		BITOK tel +49 921 555 620 FAX +49 921 555 799
Autumn 1996	Hydrology in the humid tropic environment international symposium		Kingston, Jamaica		Ivan Johnson tel/fax +1 303 425 5610
9-13 September 1996	Urban storm drainage 7th international conference	Joint Committee on Urban Storm Drainage IAHR/IAWQ	Hanover, Germany	closed	Prof Friedhelm Sieker 7th ICUSD Institut fuer Wasserwirtschaft Universitaet Hannover Appelstrasse 9A d 30167 Hannover Germany
11-12 September 1996	Multiple land use and catchment management	Macaulay Land Use Research Institute	Aberdeen, Scotland		Dr Sue Bird Tel +44 1224 318611 Fax +44 01224 311556

Date	Title	Organiser	Location	Abstracts	Contact
16-18 September 1996	Groundwater and land-use planning	Centre for groundwater studies	Fremantle WA	poster 30/5/96	tel (09) 450 1662 fax (09) 450 2942
21-22 September 1996	Defending the environment	Australian Centre for Environmental Law (ACEL)	University of Adelaide	15/4/96	
22-28 September 1996	Wetlands International Conference	University of Western Australia	Perth WA		UWA Extension Conference and Seminar Management, University of Western Australia, Nedlands WA 6009
25-27 September 1996	Modelcare '96: Calibration and reliability in groundwater modelling international conference	IGWC/IAHS/IAH	Golden (Colorado), USA	closed	Conference Secretariat ModelCARE'96 tel + 1 303 273 3103 fax +1 303 384 2037 email igwmc@mines.colorado.edu
September/October 1996	Large scale patterns and process in root system structure and dynamics workshop	Joint BAHC/BCTE/IGBP/DIS	Maryland USA		Dr Bhaskar Choudhury tel +1 301 286 5155 fax +1 301 286 1758
29 October- 7 November 1996	Water resources and environmental research towards the 21st century		Kyoto,Japan		Prof Takuma Takasao, Water Resources Research Centre, Kyouto University, Gokasho Uji, Kyouto 611, Japan
9-15 October 1996	Australian Water Industry Executive Program	AWWA	Monash University, Melbourne		Pauline Camilleri Tel (03) 9215 1110 Fax (03) 9572 3691
4-7 November 1996	Interactions between the hydrological cycle and land use cover international symposium	IGBP/BAHC/LUCC	Heian Kaikan, Japan		Dr M Sugita Tel +81 298 53 2537 fax +81 298 53 2562
10-14 March 1997	Regionalisation in hydrology international conference		Braunschwieg, Germany		Prof Dr K Hofius tel +49 0261 1306 313 fax +49 0261 103 6422
23 April-3 May 1997	5th Scientific Assembly of the International Association of Hydrological Sciences	International Association of Hydrological Sciences	Rabat, Morocco	15/3/96 (symposia) 15/1/96 (workshops)	
16-21 May 1997	Water in the balance	Australian Water and Wastewater Association	Melbourne VIC	12/4/96	
21-27 September 1997	Groundwater in the urban environment: XXVII Congress	International Association of Hydrogeologists	Nottingham, Britain		Conference Nottingham tel +44 115 985 6545 fax +44 115 985 6612
30 September - 3 October 1997	Flow regimes from international experimental network data. 3rd international conference (regionalisation of hydrological parameters and integrated catchment management)	for UNESCO/WMO by National Committee of Slovenia, the Steering Committee of the Alpine Mediterranean Hydrology FRIEND project and IAHS	Postojna, Slovenia	closed	Conference Secretariat c/- Dr Mitja Brilly tel + 386 61 1254 333 fax +386 61 219 897 email mitja.brilly@uni-lj.sl