SA waterbulletin

ISSN 0258-2244 Volume 20 No 6 November/December 1994

RIVERS RESEARCH
River scientists develop new instream flow model

BESPROEIING
Nuwe formules kan boere help met besproeiingsbestuur

HYDROLOGY
Effects of urbanisation on catchment waterbalance studied

The Institude for Groundwater Studies
presents
A Short Course in Groundwater Modelling

Flow and Mass Transport

by

Wolfgang Kinzelbach

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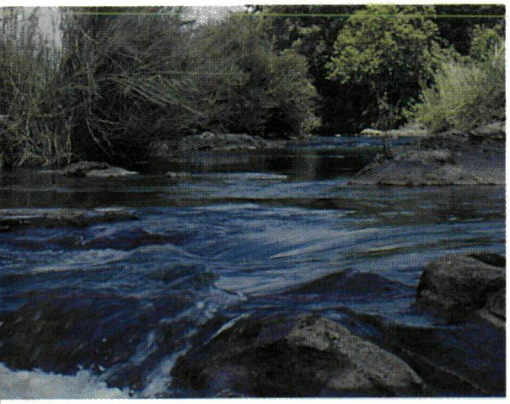

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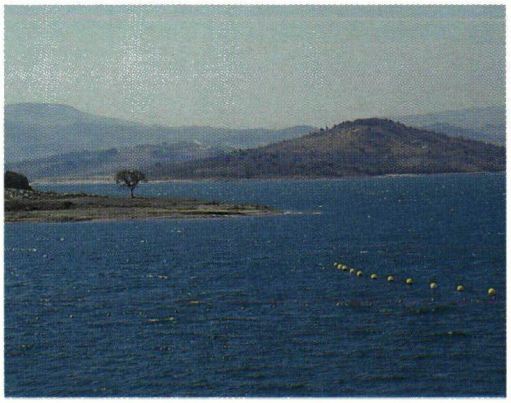

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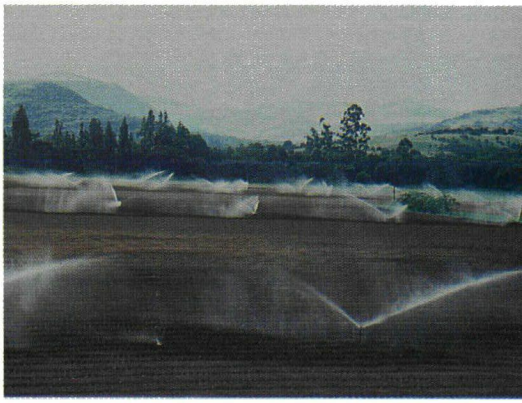

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Cover: Boat on the Berg River delta at Velddrift, Western Cape. (Photo: Helene Joubert)

SA Waterbulletin is a two monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source. Editorial offices: Water Research Commission, PO Box 824, Pretoria 0001, Republic of South Africa. Tel (012) 330-0340. Fax (012) 331-2565. Editor: Jan du Plessis. Asst Editor: Helene Joubert. Ed Secretary: Rina Human. Layout: Prepress Images, Pretoria. Colour Separations: Lithotechnik. Printing: Beria Printers.

Die SA wateringenieur en HOP onder die soeklig

'n Eendagseminaar oor die impak van die heropbou en ontwikkelingsprogram (HOP) op die wateringenieur in Suid- Afrika is einde Oktober deur die Tegniese Divisie vir Waterverspreiding van die Suider-Afrikaanse Waterinstituut, in Kemptonpark aangebied.

Mnr Trevor Fowler, 'n lid van die PWV-wetgewer, het in sy openingstoespraak die agtergrond en ontwikkeling van die HOP- program geskets en gesê die HOP is 'n meganisme vir die herskepping van die Suid-Afrikaanse gemeenskap. Dit moet daartoe lei dat Suid-Afrika vir elkeen 'n beter land word om in te leef. Hy het gesê die HOP-program is op die volgende ses basiese beginsels geskoei:

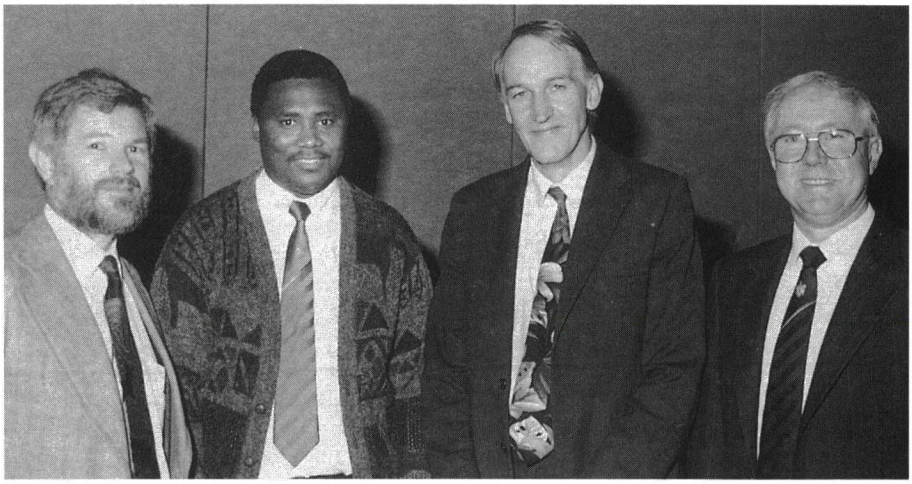
- Nasiebou - om die wonde van die verlede te genees en al die gemeenskappe in die land saam te snoer;
- Die bevordering van vrede en sekuriteit;
- Die ontwikkeling van 'n mensgedrewe proses waar die basiese behoeftes van Suid-Afrikaners sentraal sal staan;
- Die verbinding van ekonomiese herkonstruksie met ekonomiese groei en ontwikkeling;
- Die daarstelling van geïntegreerde en volhoubare groei, en
- Die verbreding van die demokrasie sodat alle Suid-Afrikaners betrek word.

Mnr Fowler het gesê die riglyne wat vir die toepassing van die HOP-program in die waterveld sal geld, sluit in:

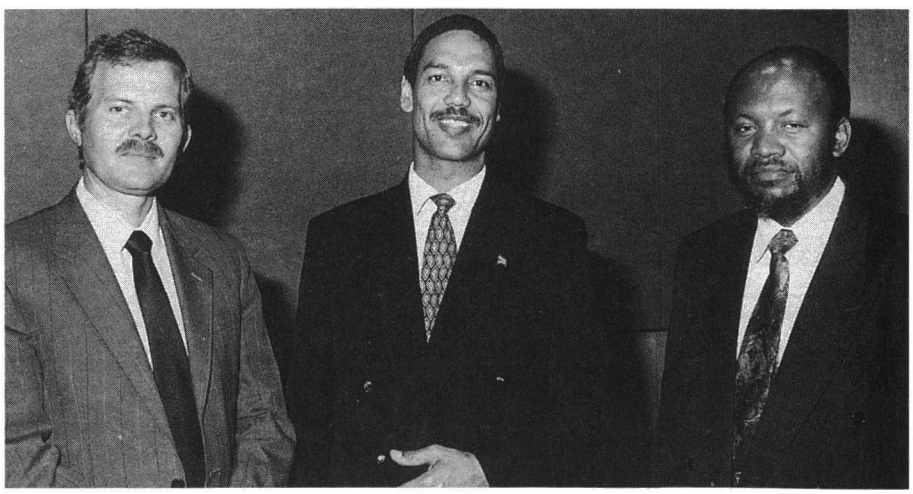
- Watersekuriteit vir alle Suid-Afrikaners;
- Die ontwikkeling van gemeenskapsgebaseerde waterprojekte;
- Die beklemtoning van die ekonomiese waarde van water; en
- Streeks-waterverspreiding.

Volgens mnr Fowler sal wateringenieurs wat in die toekoms by gemeenskapsprojekte betrokke raak 'n holistiese benadering moet volg in die wete dat waterver-

Sprekers tydens die eendagseminaar oor die heropbou en ontwikkelingsprogram.



Van links: Mnr Barry Jackson (NOWEP), mnr SN Makhetwa (Ontwikkelingskonsultant), mnr P Cross (Mvula Trust) en mnr Peter Coetzee (WISA).



Van links: Mnr N Macleod (Durbanse Stadsraad), mnr T Fowler (PWV-Wetgewer) en mnr P Nhlapo (Umgeni Water, Pietermatitzburg).

skaffing slegs een aspek is van die totale behoeftes van die gemeenskap waaraan voldoen moet word. Projekte moet gemeenskapsgedrewe wees en opgegradeer kan word namate die ekonomie groei, het hy gesê.

Mnr Mike Muller van die Departement van Waterwese en Bosbou het die nuwe Witskrif oor water en sanitasie bespreek en mnr Neil Macleod van die Durbanse Stadsraad het 'n voordrag gelewer oor die aanpassings wat nodig is om te voldoen aan die vereistes van die HOP vir waterverspreiding in metropolitaanse gebiede.

Ander sprekers was mnr P Nhlapo van Umgeni Water met 'n referaat oor watervoorsiening en sanitasie in plattelandse en buite-stedelike gebiede, mnr SN Makhetha, 'n ontwikkelingskonsultant, wat gepraat het oor 'n raadgewende ingenieur se siening van die inwerkingstelling van die HOP, mnr P Cross van die Mvula Trust met 'n oorsig van die Trust se werksaamhede gedurende die eerste jaar waarin hulle landelike gemeenskappe gehelp het om water en sanitasie-dienste te verbeter en mnr B Jackson van die Nasionale Openbare Werke- program (NOWEP) wat NOWEP se benadering tot water en sanitasieprojekte geskets het.

Mnr Jackson het gesê NOWEP word deur die regering beskou as 'n integrale deel van die HOP-program en bestaan uit twee hoofelemente, naamlik:

- Toegewysde fondse vir gemeenskapsgebaseerde OWEP-projekte wat deur plaaslike gemeenskappe geïdentifiseer en geïmplementeer word; en
- Die sistematiese heroriëntering van die openbare sektor se befondsingspatrone en metodes na die NOWEP benadering van arbeidsintensiewe projekte wat opleiding verskaf en kapasiteit bou asook die benutting van plaaslike hulpbronne en ondernemers.

Beide hierdie elemente, sê mnr Jackson, hou aansienlike implikasies in vir diegene wat waterverskaffing en sanitasieverbeteringsprojekte beplan.

WRC appoints new research manager

The Water Research Commission recently appointed Mr Zola (Zolile) Ngcakani as research manager.

Mr Ngcakani was born at Herschel in the Eastern Cape but grew up in Thaba Nchu in the Orange Free State (OFS) where he attended primary school at the St Paul's Practising School. He matriculated in 1957 at the St Boniface High School in Kimberley.

He subsequently studied towards a BSc degree at the University of Fort Hare, majoring in physics and chemistry. In 1961 he received a scholarship to continue his studies abroad in Russia (the then USSR). After six months of learning Russian at the Language Preparatory College in Kiev, he then enrolled at the Institute of Chemical Technology in Leningrad and graduated in 1967 with a diploma in Chemical Engineering.

Mr Zola Ngcakani

Thereafter he returned to Africa in 1968, going to Lusaka via Tanzania where he was involved with community development work and small scale sanitation and water supply projects in ANC camps. In Lusaka, however, mr Ngcakani says he was involved in fulltime political organisational work.

In 1974 the World Health Organisation (WHO) awarded mr Ngcakani a fellowship to do a masters degree in Environmental Health Engineering at the University of Nairobi, Kenya.

Thereafter he lectured in the Department of Civil Engineering at the University of Nairobi, from 1976 till 1984.

Zola Ngcakani and his family then emigrated to Canada. In 1986 he once again took to studying, this time at the University of Western Ontario, in the Department of Food and Biochemical Engineering, completing yet another MSc in engineering in 1988.

In 1989 he was appointed as senior review engineer in the Approvals Branch: Industrial Wastewater, of the Ministry of the Environment in the Ontario province. In this capacity he dealt with the review and approval of proposals and plans for industrial effluent management submitted by a variety of industries.

Recently he returned to South Africa to join the Water Research Commission as Research manager: industrial water and wastewater

Mr Ngcakani's wife, Pulane, is a qualified nurse. She studied at McCord Zulu Hospital in Durban and later she specialised in midwifery in Birmingham, England. They have five children, of which the youngest is twenty and the eldest twenty nine. "Unfortunately they are all in Canada", says Mr Ngcakani.

In his free time he enjoys sport and plays tennis. Another favourite pastime with him is choral singing, having sung in a number of choirs during his years abroad.

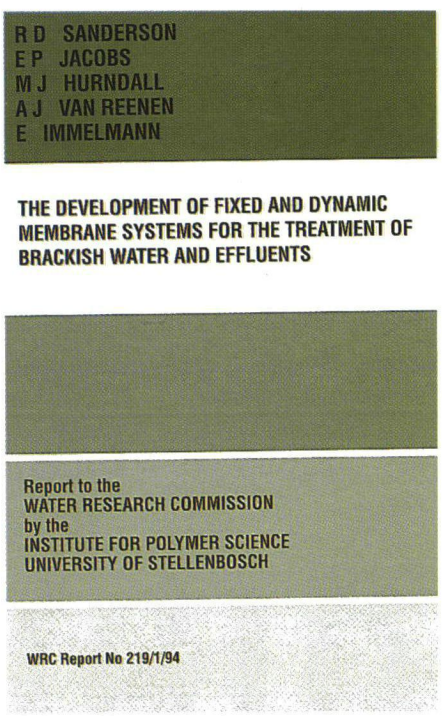
NEW MEMBRANE TECHNOLOGIES FOR TREATING INDUSTRIAL EFFLUENTS

South Africa has limited supplies of one strategic commodity that affects the lives of all the inhabitants of the country, namely, water. Scientists working in the water field, therefore, are compelled to make South Africa self-sufficient with regard to technologies that can be used to augment the volume of water available for use.

This is said in a report compiled by the Institute for Polymer Science at the University of Stellenbosch on the "Development of fixed and dynamic membrane systems for the treatment of brackish water and effluents". The researchers RD Sanderson, EP Jacobs, MJ Hurndall, AJ van Reenen and E Immelmann, say that in the field of membrane systems, membrane scientists can play a key role in making the country self-sufficient in the areas of waste water management, water treatment and by-product recovery. This has already been demonstrated by the successful commercialisation of the locally developed tubular cellulose acetate membrane system and by the advances made with ultrafiltration systems.

The report says that although South Africa has made great progress in effluent treatment, newer and more advanced techniques are required and therefore further aspects of membrane separation processes should be considered. Membrane scientists need to ensure that the local membrane industry will have a full range of processes and products from which to choose to meet specific customer requirements, as well as the expertise to handle South Africa's water associated problems which exist at present and which will escalate in the future.

Membrane scientists should be able to offer more than one solution to any effluent problem in order that an optimum and economical solution can be found. It is imperative not merely to make paper findings but also to prove the viability of findings in the field. The report says it is therefore important for industry to be able to get a partial "package" from the research effort before they go into production. It is suggested that this "package" should include the know-how of how to fabricate selected membranes and limited on-site effluent evaluation, with consideration for such aspects such as ageing, fouling and cleaning of the membrane.



Since there is now a local commercial company which can handle basic membrane fabrication processes, for example, the production of tubular cellulose acetate membranes, the report states that the time is ripe for progress to be made in other directions. It is important to make membranes which can be used in the treatment of specific effluents such as phenolic waste streams from Sasol, fish-stick waste water, dairy whey and winery effluent.

The viability of products and technology developed in contracts entered into with the Water Research Commission in the past have been proved in the industrialisation of membrane processes which have provided solutions to many industrial problems.

PROJECT

The results of the research project summarised in this report emanated from a diversity of objectives for the contract period 1988 to 1990. These included the following:

- The improvement of existing cellulose acetate membrane technology;
- The improvement of polyarylether sulphone ultrafiltration membrane technology;
- The fabrication of reverse osmosis poly-2-vinylimidazoline membranes;
- An investigation into non-nitrogen containing ultra thin film reverse osmosis membranes;
- Dynamic membrane polymer development;
- The development of a low-cost high-pressure dynamic membrane module;
- The establishment of production techniques for thermal phase inversion membranes, and
- The development of a fabrication technology for 0,5 to 2 mm diameter micropore polypropylene and polyarylether sulphone tubulettes.

According to the researchers most of the aims have met with a good measure of success. Some have been successfully concluded while several warrant further investigation after initial good results.

Copies of the report "The development of fixed and dynamic membrane systems for the treatment of brackish water and effluents" (WRC report 219/1/94) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: $25.)

Submission of research proposals to the Water Research Commission

Voorlegging van navorsingsvoorstelle aan die Waternavorsingskommissie

Soos in die verlede rig die Waternavorsingskommissie (WNK) 'n uitnodiging aan navorsingsinstansies om met die oog op finansiering van die navorsing vanaf 1996 voorstelle vir waternavorsingsprojekte by die WNK in te dien. Anders as in vorige jare is die sluitingsdatum vir die indiening van die voorstelle 30 April 1995.

LET ASSEBLIEF DAAROP DAT LAAT INDIENINGS ONDER GEEN OMSTANDIGHEDE AANVAAR SAL WORD NIE.

Die toenemende aantal voorleggings wat die WNK ontvang en die gepaardgaande toename in tydsdruk om navorsingsvoorstelle te prosesseer, het dit ook nodig gemaak dat die formaat van die voorleggings verander. In plaas van die opsommende navorsingsvoorstelle wat in die verlede ingedien is, moet gedetailleerde volledige navorsingsvoorstelle die WNK nou reeds teen 30 April 1995 bereik. As gids in hierdie verband is die WNK se "Riglyne vir die opstelling van navorsingsvoorstelle" op aanvraag beskikbaar.

Die WNK wil sover moontlik indiening van voorleggings in 'n elektroniese formaat aanmoedig. 'n Voorafopgestelde vorm op rekenaardisket sal op versoek vir hierdie doel beskikbaar gestel word. Navorsers wat van hierdie geleentheid gebruik wil maak, moet asseblief die soort en grootte van die disket spesifiseer (sagteskyf 360K/1,2 Meg of stiffie 720K/1,4 Meg).

Alle voorstelle sal gesamentlik na 30 April 1995 oorweeg word. Indien nodig, sal die betrokke WNK-navorsingsbestuurder na die sluitingsdatum met die indiener van die voorstel in verbinding tree ten einde onduidelikhede op te klaar en die voorstel af te rond. Uiteindelik sal hierdie finale voorlegging tydens 'n vergadering van die Kommissie oorweeg en 'n aanbeveling oor die finansiering daarvan aan die Minister van Waterwese en Bosbou gemaak word.

Navorsers in die waterveld word aangemoedig om moontlike navorsingsvoorleggings met die WNK se navorsingsbestuurders te bespreek voor dit aan die WNK voorgelê word.

As in the past the Water Research Commission (WRC) is extending an invitation to research organisations to submit water research proposals to the WRC with a view to funding thereof during 1996. Unlike previous years the final date of submissions will be 30 April 1995.

PLEASE NOTE THAT LATE SUBMISSIONS WILL NOT BE ACCEPTED UNDER ANY CIRCUMSTANCES.

The growing number of research proposals being received by the Water Research Commission and the time pressure involved in processing and evaluating the submissions, also made it necessary to change the format in which proposals should be submitted. Instead of proposals in summary form as was required in the past, detailed complete research proposals must now reach the WRC by 30 April 1995. As an aid in this regard the WRC's "Guidelines for compiling research proposals" is available for information and use by researchers.

The WRC would like to encourage submissions in an electronic format, where possible. For this reason, a computer disk containing a pre-compiled submission form will be made available on request. Those researchers wishing to avail themselves of this opportunity should contact the WRC in this regard and specify the type and size of disk required (floppy 360K/1,2 Meg or stiffy 720K/1,4 Meg).

All proposals received will be considered jointly after 30 April 1995. Following this date, if necessary, the WRC research manager concerned will liaise with the proposer of a project in order to clarify any vagueness that may exist in the proposal and to finalise it. The finalised proposal will then be considered at a meeting of the Commission and a recommendation will be made to the Minister of Water Affairs and Forestry regarding the funding thereof.

Researchers in the water field are encouraged to discuss potential research proposals with the WRC's research managers prior to submission.

The Sable River at Sablepoort
in the Kruger National Park

RIVER SCIENTISTS DEVELOP NEW INSTREAM FLOW MODEL

A synthesis report of methodologies presently available for instream flow assessments has recently been released by the Water Research Commission (WRC). This comprehensive work entitled Assessment of the Instream Flow Incremental Methodology, and Initial Development of Alternative Instream Flow Methodologies for South Africa was compiled by Dr Jackie King and Rebecca Tharme, Freshwater Research Unit, University of Cape Town. The report emanates from the project "Assessment of instream flow requirements of rivers" that was funded by the Water Research Commission.

In this project the Instream Flow Incremental Methodology (IFIM) was applied and tested in a South African situation which presented the local realities and problems of assessing the water requirements of rivers. The researched showed that neither IFIM, nor the analyses of daily flow records obtained from the Department of Water Affairs and Forestry, provided the means to produce a recommendation of a comprehensive modified flow regime for a regulated river according to the requirements of the Department of Water Affairs and Forestry.

However, according to the report the development of an alternative methodology has started to evolve, for situations where there is little time, money or data available for such research. This new methodology is being developed in liaison with other river scientists and Department of Water Affairs and Forestry personnel.

The researchers say that the Kruger National Park Rivers Research Programme is greatly contributing to a more comprehensive approach to assessment of the water requirements of rivers.

In conclusion the report emphasises that these initiatives in the newly developing science of instream flow assessments needs to be supported, and that collaboration with similar expertise in other countries be encouraged.

The report, **Assessment of the Instream Flow Incremental Methodology, and Initial Development of Alternative Instream Flow Methodologies for South Africa** (WRC report no 295/1/94) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. Please note: Foreign orders will be charged a list price of US$ 30.

There is a growing concern worldwide regarding the increasing rate of deterioration of the natural environments of rivers. In the past, much of this concern has focussed on water quality problems, and only recently has the manipulation of flow regimes been recognised as a major factor affecting the health of rivers. Some countries, including South Africa, have now initiated activities to address the damage caused by modified flow regimes that do not cater for the water needs of the riverine ecosystem. From these activities the new science of instream flow assessments has developed, whereby recommendations are made on modified flow regimes for rivers involved in water-resource developments. Although such assessments are usually made when new developments are planned, it can equally well be done for extant developments in order to guide moves to halt or reverse deterioration of the river concerned.

South Africa's first acknowledgement of the problem at a national level came in 1987, with two major workshops on assessing the water requirements of rivers. The project reported on here evolved directly from the activities related to these two workshops. Its objective was to critically assess the Instream Flow Incremental Methodology (IFIM) and thereafter, if required, to initiate the establishment of one or more scientifically acceptable methodologies for assessing the instream flow requirements of the country's rivers.

IFIM

IFIM was devised by the United States Fish and Wildlife Service. It comprises a collection of analytical procedures and computer programmes and includes the Physical Habitat Simulation Model, PHABSIM II, which is its best known component. In its entirety IFIM is said to evaluate the effects of incremental changes in stream flow on channel structure, water quality, temperature and availability of this physical microhabitat for selected target species. Information on the availability of this physical microhabitat, which is simulated by PHABSIM II, is actually the principle product of applying the methodology, and is used in negotiations for an acceptable discharge or modified flow regime for the river of concern.

The focus of IFIM is PHABSIM II, which acts much like any hydraulic model by simulating hydraulic conditions over a range of discharges, but is unusual in that these simulations are then linked to habitat information on selected riverine

Photo: Helene Joubert

species. The model uses the concept
- that physical flow-related conditions at the micro-habitat level can be measured and, using this information to calibrate the model, then simulated over a chosen range of discharges;
- that the instream areas where the selected target species most often occur, termed the preferred habitat(s), can also be measured at the microhabitat level, using the same variables;
- that these two sets of information can then be linked, to illustrate how much flow-related microhabitat is available to the species over the chosen range of discharges.

To produce this output, the model uses measured data
- on the channel morphology of selected sites, and
- on the hydraulic characteristics of flow through those sites,

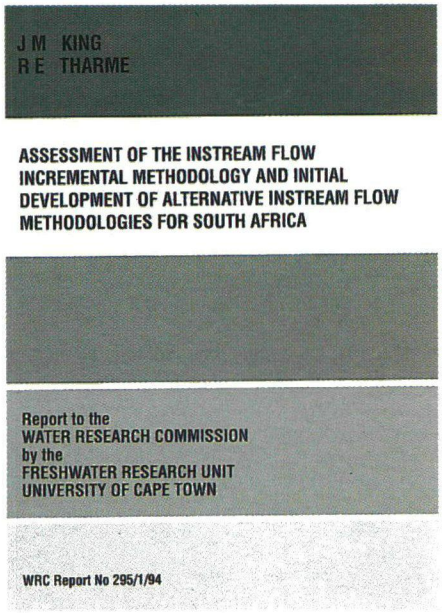
to simulate conditions of water depth, water velocity, as well as substrate, hydraulic and vegetal cover over the range of discharges. The substrate and cover conditions together are termed the channel index (CI).

Simulations are done at a level of resolution deemed to be ecologically relevant, by compartmentalising the study sites within the model into a grid of cells. Once the hydraulic simulations are complete, each cell within PHABSIM II has a value for water depth, water velocity and channel index for each of the discharges which the model was programmed to simulate.

IFIM IN SOUTH AFRICA

The project team established PHABSIM II study sites in the three major zones of the Olifants River (Western Cape), creating fixed transects surveyed into trigonometrical beacons which were used to describe channel morphology. On three occasions the team collected cell-by-cell water depth, velocity and channel index (CI) data along the transects, as well as relevant discharge related data, in order to calibrate and run the model.

At the same time, seven additional sites along the mainstream and three on selected tributaries were established. These and the three PHABSIM II sites were used together for two purposes. First, samples of bottom-living (benthic) aquatic invertebrates were collected at each of the 13 sites, and their flow-related habitat conditions recorded, in the four seasons: winter, spring summer and autumn. This information was used to determine the preferred microhabitats for each of several selected invertebrate target species, to be used in PHABSIM II.



Secondly, water quality samples and additional features of the sites were collected at every site on every visit. These were used in conjunction with the information on invertebrate distributions gained from the field trips, and office data on the general hydrology and geology of the catchment, to refine the delineation of macrohabitat zones within the three major zones initially identified.

Fish are the traditional choice as target species for use in IFIM, and are the ecosystem component of most concern in the Olifants River. The preferred microhabitats of selected fish species were thus also recorded for use in PHABSIM II.

The field data on channel morphology, cell-by-cell hydraulics and other relevant data for the fish and invertebrate target species were combined using PHABSIM II. The output from the model consists of plots of Weighted Usable Area versus Discharge (WUA-Q) for each target species.

These predictions illustrate both present weighted usable area and, assuming that channel morphology and substrates do not change with water resource development, the future availability of weighted useable area after such a development.

However, during the project it became obvious that IFIM was incomplete and could not provide a recommendation for a comprehensive modified flow regime. Therefore the development of two alternative potential methodologies began.

METHODOLOGIES

In the first initiative the daily flow data were used to search nationwide for rivers with similar flow patterns. This has been done before in South Africa, but not at the level of resolution required for ecological work, where the specific flows that the biota are experiencing are more relevant than some coarser statistic of flow. It was hoped that similar rivers would group regionally, so that extrapolations regarding flow patterns could be made from known to unknown rivers within a region.

Two different methods were used to analyse the data. Method One used cluster and discriminant analysis. While Method Two used correspondence analysis and covariance biplots. Method One can be used to group rivers that are similar, while Method Two can be used to group rivers that are, perhaps, less similar but occur within defined geographic regions.

Using both Methods, the daily flow data for almost 300 gauging stations recording near- natural flow were investigated in two forms. First, similarities in seasonal flow patterns were sought by comparing the proportions of annual flow occuring in each calendar month. Secondly, similarities in flow types were sought, using derived variables of flow which were considered to be ecologically significant, such as the coefficient of variation and the number of days of zero flow.

Reedbeds in the Sabie River

Aerial view of the Sabie River

The research revealed that, based on the monthly proportions of flow, only three major geographical super-regions could be identified: the winter rainfall area in the south-west Cape, the aseasonal rainfall area in the southern Cape, and the summer rainfall area in the rest of the country. Method Two, because of its iterative approach, was then used to create regions within the summer rainfall super-region, which were based on catchment boundaries and somewhat similar flow patterns. Both Methods produced statistics of flow which described each of their groups.

The results support the findings of similar research in other countries, showing that several types of flow patterns occur within any one geographical area.

Nevertheless, it is quite possible that there will be a future need to group similar rivers, in order to extrapolate from known to unknown situations. It is therefore recommended that methodologies be further developed that do not necessarily require such groups to have geographical boundaries.

BUILDING BLOCK METHODOLOGY

The second initiative, termed the Building Block Methodology, concerns a methodology that is being developed by river scientists involved in the Instream Flow Assessment workshops run by the Environment Studies subdirectorate of the Department of Water Affairs and Forestry. The methodology is designed to be used in such workshops, in situations where time, money and relevant biological data are limited. It is based on the assumption that species associated with a river can cope with baseflow conditions that naturally occur in it often, and may be reliant on higher flow conditions that occur in it at certain times, such as specifically-timed floods. It is further assumed, though largely untested as yet, that identifying such flow conditions and ensuring that they are incorporated as part of a modified flow regime will allow some semblance of the natural biota and associated functioning of the river to be maintained. Finally, it is also assumed that certain kinds of flow influence channel geomorphology more than others, and that incorporating such flows into the modified flow regime will aid maintenance of the natural channel structure. Thus, the recommended modified flow regime is envisaged as encompassing a framework of commonly-occuring low flows, interspersed with selected higher flows each of which adheres to natural limits of magnitude, duration and timing, and performs certain functions.

The methodology has been developed over the last two years, through use in South Africa in four workshops addressing the instream flow requirements of specific rivers. It represents, at best, a first attempt to determine the modified flow regime needed to maintain a river at some pre-determined state, but most of those involved in the workshops feel that, it is better than the two possible alternatives: to leave the assessment to those with no understanding of riverine functioning, or to make no provision at all for the river's requirement for water.

Improvement of the Building Block Methodology continues through its application at Department of Water Affairs and Forestry workshops and through focussed research projects presently underway in the country. This research and development has greatly benefitted from the expertise and input of the Australian river scientists. The continued close collaboration with, and assistance from, the Australian river scientists is of great value to the South African river scientists.

Researchers study effects of urbanisation on catchment water balance

The Water Systems Research Group at the University of the Witwatersrand completed a study with the broad objective to evaluate the effects of urban development on catchment water resources. In the study, which was financed by the Water Research Commission, the changes in runoff and in catchment water balance were measured and modelled enabling these effects to be generalised for transposition to other catchments. The primary effects considered were total water runoff and loss from the catchment, with assessment of both flood runoff and drought runoff.

Secondary factors considered were flood volumes and peaks, water levels in streams and the variations in ground water levels due to abstractions. The ability to transport water pollutants and effects on groundwater quality were also assessed.

The effect of impermeable covers such as roads and buildings was investigated, together with the construction of drains resulting in different hydraulic resistances, different gradients and more rapid runoff. At the same time water reticulation systems and sewerage runoff and their effect on the catchment water balance has been investigated.

REPORTS

The project gave rise to a number of reports, all of which are available from the Water Research Commission, PO Box 824, Pretoria 0001, free of charge. The reports can be ordered separately or as a set. The overseas price is shown in brackets in the list below. The reports are:

- ❑ **Analysis of effects of urbanisation on runoff** (WRC report 183/1/93) by D Stephenson. ($20
- ❑ **Description of catchments and methodology** (WRC report 183/2/93) by JJ Lambourne and T Coleman. ($20)
- ❑ **Geohydrology of catchments** (WRC report 183/3/93) by WAJ Paling and D Stephenson. ($25)
- ❑ **A hydrometeorological data management package - WITS data management system WITDMS** (WRC report 183/4/93) by JJ Lambourne. ($20)
- ❑ **The effect of storm patterns on runoff** (WRC report 183/5/93) by N Patrick. ($20)
- ❑ **A physically based hydrological model for continuous simulation of catchment runoff** (WRC report 183/6/93) by A Holden. ($30)
- ❑ **Streamflow modelling** (WRC report 183/7/93) by P Kolovopoulos. ($30)
- ❑ **Runoff management modelling** (WRC report 183/8/93) by TJ Coleman and D Stephenson. ($30)
- ❑ **Catchment water balance** (WRC report 183/9/93) by JJ Lambourne, TJ Coleman and D Stephenson. ($20)
- ❑ **Urban runoff quality and modelling methods** (WRC report 183/10/93) by T Coleman. ($10)
- ❑ **Compendium of papers published by the Water Systems Research Group on the project results** (WRC report 183/11/93). ($30)

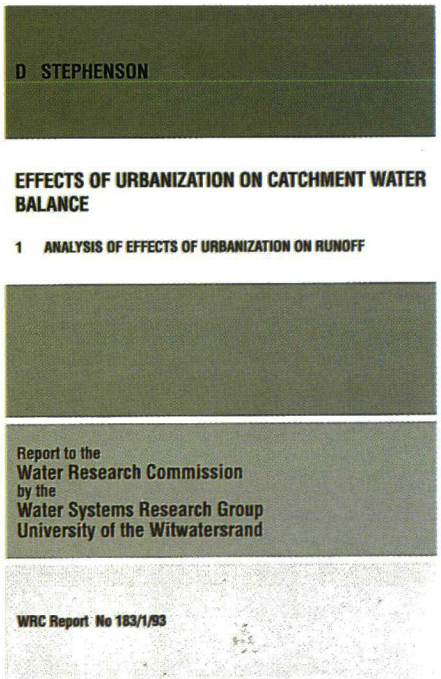
- ❑ **The complete set of reports, including the Executive Summary by D Stephenson.** ($200).

According to the reports the general method the researchers used to assess the effects of urbanisation on the catchment water balance was to compare two catchments, one which was natural veld and the other which was urbanised i.e. a residential suburb. The catchments were adjacent with similar geology and of the same order in size, shape and slope. Observations were made over a period of five years and it is expected that any variation due to isolated storms would be averaged out in this period so that only the effects of urbanisation would result in differences in runoff and water balance. Rainfall was measured at a number of raingauges in the catchment and runoff was monitored at the downstream end of each catchment. Although the effects of different factors in the urban catchment was not measured directly the different factors were distinguished by means of modelling, using a computer programme.

If the catchments were identical before urbanisation of one, then the results of the research exhibited the effects of urbanisation. Unfortunately, the experiment was not started until after the urban catchment was essentially developed. The researchers say it is anticipated that a future contract will investigate the gradual urbanisation of a third adjacent catchment so that the research will eventually be three-cornered and cover the possibility that the two catchments were dissimilar in factors other than urbanisation.

CATCHMENT DESCRIPTION

The catchments were situated at the northern extremity of the municipality of Sandton, near Johannesburg. The urban catchment is in Sunninghill, a suburb of Sandton, and the rural catchment is on the Waterval farm to the north. The catchments were each 75 ha in size and are situated on a bushveld granitic base. There are dolomite dykes crossing the catchments and the soil is generally sandy decomposed granite.



The vegetation on the undeveloped rural catchment is essentially grass with some clumps of gum trees. The undeveloped catchment has no defined water courses except at the bottom end where the water is collected by means of a furrow and passes over a measuring weir.

The urbanised catchment is middle class housing with a small shopping complex and part of the ESKOM Megawatt Park complex. The housing is primarily single storey, separate bungalows in gardens varying in size from 1 000 to 2 000 m^2.

There are some townhouses and townhouse development progressed during the period of monitoring. The urbanised catchment has running down the middle a park strip with a man-made channel lined with gabions in places. The water is collected in a culvert at the downstream end and a crump weir was constructed under the project to monitor the outflow. Water supply to the area is monitored by a municipal meter which is read at three-monthly intervals. Sewage outflow is monitored in a manhole at the downstream end of the catchment.

A dolerite dyke across the lower extremity of the urbanised catchment forces groundwater to the surface and artesian conditions are observed.

The mean annual rainfall of the catchment is some 700 mm and this falls primarily in the summer months October to March.

MONITORING PROCEDURES

Sixteen boreholes were drilled over the catchments in order to monitor groundwater fluctuations. Eight autographic raingauges with data loggers attached, monitored the rainfall over the catchment. Data loggers monitored the flow rate over the weirs at the end of each catchment and another data logger monitored the sewage outflow. Raingauges were the tipping bucket type and stream gauges the depth sensor type. A rating curve converting flow depths to flow rates was used with a computer programme to interpret the results. Numerous problems were found with the electronic data loggers with the result that a lot of earlier data was missed. It was therefore necessary to use later data to obtain a rainfall runoff relationship in order to extrapolate back the runoff flows.

The borehole water levels were monitored by manual methods initially and sometimes with electronic sensors at a later stage.

The catchments were investigated geologically using borehole logs and in the case of the Waterval catchment resistivity and magnetic surveys for identifying dykes and discontinuities.

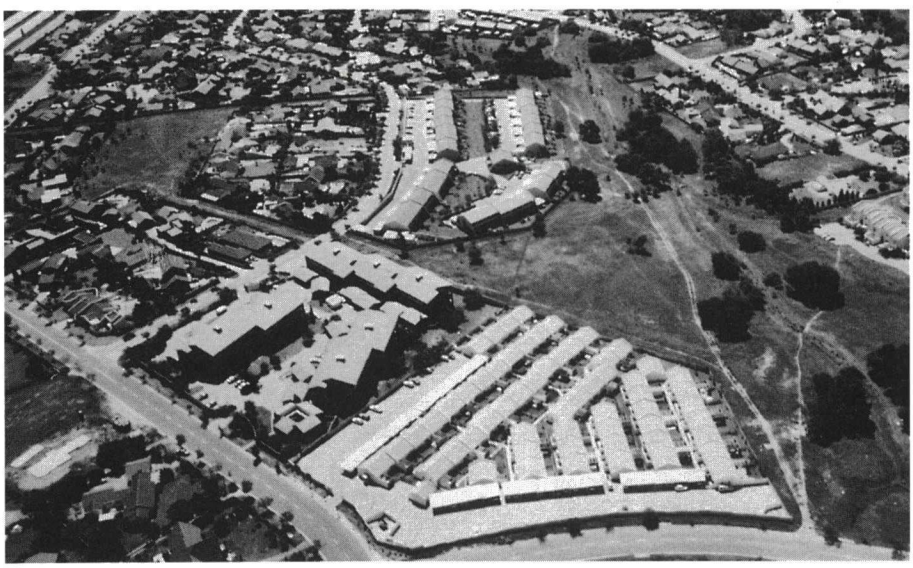
A weather station was installed in the Waterval undeveloped catchment. Here wind speed and direction were monitored as well as temperature, solar radiation, evaporation, barometric pressure and relative humidity from August 1987.

TECHNOLOGY

In order to distinguish between the different methods of affecting runoff a digital computer model was prepared. This model was based on the hydrodynamic laws and allows for multiple units in the drainage process, that is, it is able to connect impervious and pervious catchments, groundwater layers and conduits. Rainfall input can be obtained from the records received and simulated storms can also be fed in. The computer model predicts the flow rate throughout a storm and afterwards, at any selected location. The model is able to account for management methods in attenuating and concentrating storms. Dual drainage, whereby water would overflow underground sewers and run down the roads is accounted for, as well as attenuation due to flood drains such as down the central channel in the urbanised catchment, Sunninghill. Surface roughness and conduit configuration is supplied in the data sheets in the reports. The model is now used by researchers and consultants throughout the country for studying stormwater attenuation and runoff from urban catchments. It is also suitable for use with rural catchments.

A continuous modelling exercise was also undertaken for estimating long term effects of rainfall. A model which is able to account for soil moisture and changes in groundwater and perched water levels was thus prepared.

Waterval catchment



Sunninghill suburban catchment

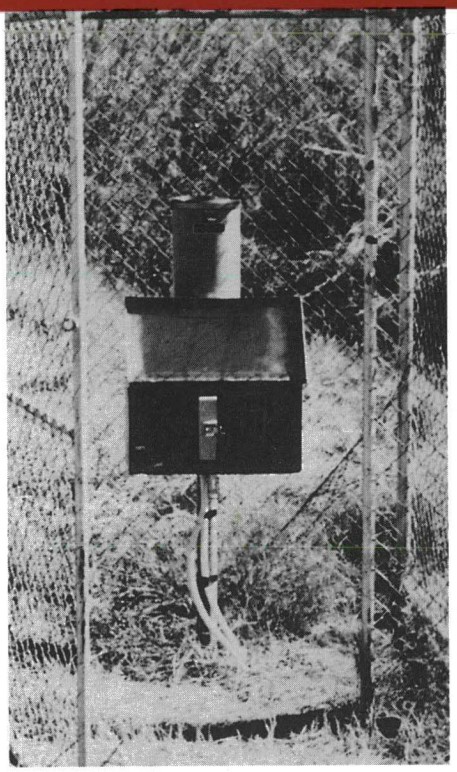
A data management computer package was also prepared. This was necessary to read data from the chips coming from the data loggers. The program converted the signals to rainfall records and filed the data for subsequent analysis. The program is also able to analyse chart recorder data. This rainfall data is digitised and stored in similar tables to that from the electronic data loggers. A program for simulating river flow was also prepared. This program accounts accurately for water surface profile variations in unsteady flow conditions. It routes flow down channels and accounts for momentum transfer and flow transfer to flood plains and predicts the effect of the additional friction in retarding floods. The raingauges situated throughout the

catchments provided data for studying storms patterns. Research into the movement of storm patterns was undertaken and a computer program for contouring storms as they travelled across the catchments and changed, was prepared.

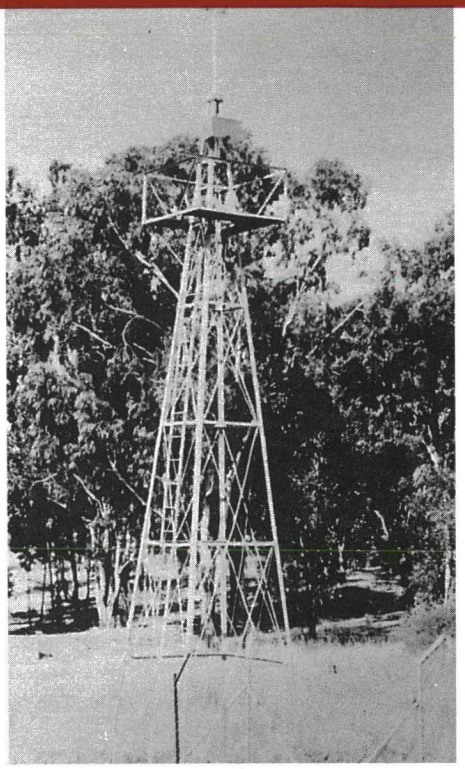
Initial steps were taken to study runoff water quality by means of computer models. Water quality analyses from a catchment in Hillbrow was made in order to test this model. The model will also be used by the CSIR for analysing data from catchments in Pinetown, Natal.

RESULTS

The results of the study indicated that stormwater runoff for developed catchments was increased by a factor of up to four over that from an undeveloped catchment. This is largely because of the construction of roads and roofs which channelises the flow and results in a faster concentration. The reduction in infiltration due to some 20 per cent of the area being covered by pavements, roofs, etc. further increased the flow rates. The layout of roads which runs directly to the bottom of the catchment concentrates the floods.



Rainguage



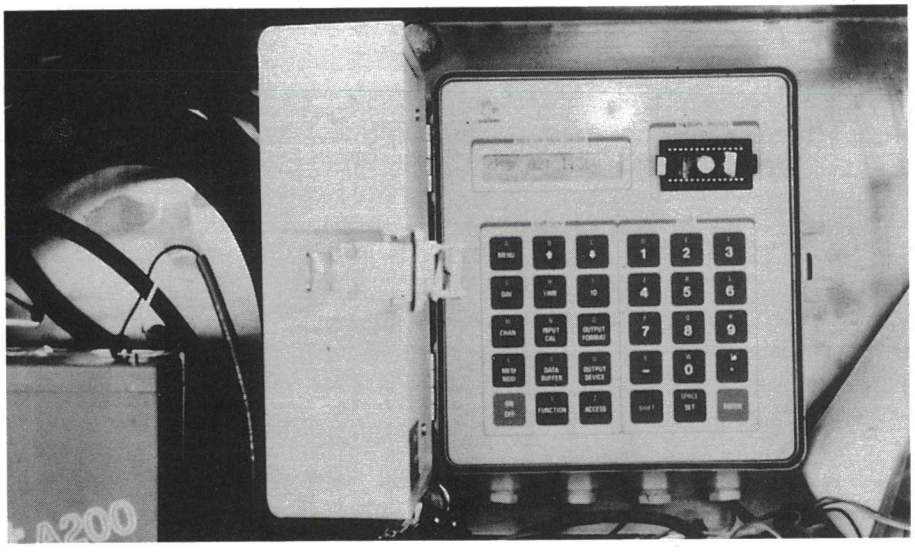
Weather Station at Waterval

The practice of leading drains from building roofs direct to paved areas and then to storm drains increases volume and intensity of runoff. The more rapid runoff also results in higher volumes of runoff and therefore less infiltration than for the natural catchment.

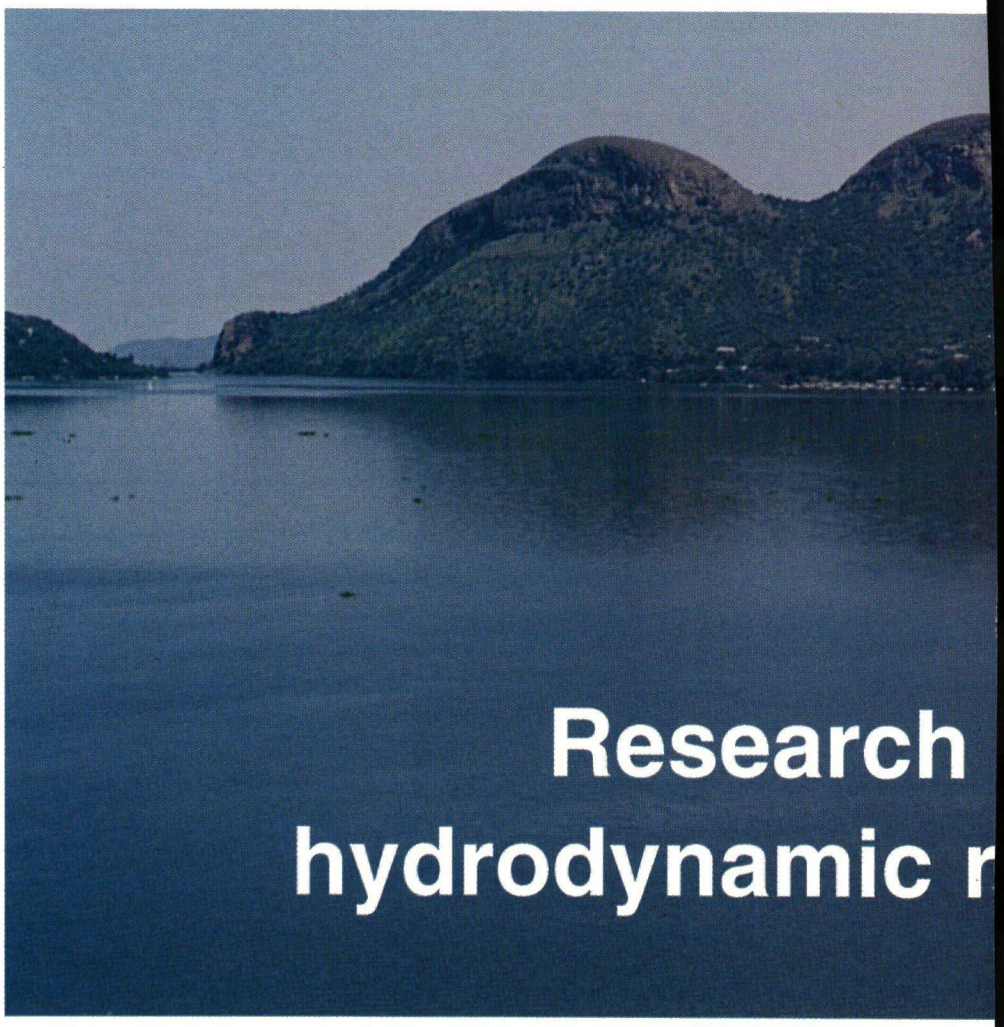
Evapotranspiration from parks and gardens in the urban catchment amounts to 55 per cent of water supply input from this catchment. This is the same as for the natural catchment despite the smaller area vegetated because of the preference for green gardens. In addition 83 per cent of the water supply to urban areas was discharged to sewers and lost to the catchment although some of this is probably illegally connected storm drainage.

There was a net loss of water from the urban catchment by a groundwater flow but this appears to be balanced to some extent by excessive garden watering. Computer models developed to assess the individual effects of urbanisation on stormwater runoff and catchment water balance can now be used for planning future drainage systems. Town planners and civil engineers will be able to minimize runoff and therefore reduce the circulation of water in the giant Witwatersrand and other urban complexes.

The results highlight the necessity for changes to town planning regulations. That is, the discharge of water from roofs should where possible be onto gardens in order to encourage infiltration. Use of dual drainage systems to enable floods to be stored on roads or preferably parks and infiltration strips is important.



Electronic Data Logger



Research hydrodynamic r

Mathematical water quality computer models for reservoirs are developed for two main reasons. Firstly, models are used as research tools to establish an understanding of the complex interactions between physical, chemical and biological processes. Secondly, models are used as management and planning tools to provide the necessary information for decisions on the abatement of water quality problems. This is said by researchers in their recent report **The applicability of hydrodynamic reservoir models for water quality management of stratified water bodies in South Africa to the Water Research Commission.**

The report says water quality is an increasingly important consideration in river system management and planning in South Africa. Many of South Africa's rivers are already highly regulated by impoundments, which, in response to the strong seasonality of the climate, stratify on a cyclical basis. Water quality patterns of these impoundments are significantly influenced by stratification. This impacts on treatment, and the cost thereof, of water abstracted from such reservoirs, while water quality patterns downstream of such reservoirs are impacted by releases from such impoundments. The interaction of processes and driving forces which determine water quality patterns in these reservoirs is complex; consequently, there has for some time been a growing awareness of the need for a greater range of decision support tools for water quality management and planning in South Africa.

In response to this need the Water Research Commission appointed Ninham Shand Inc. in association with the Department of Civil Engineering, University of Cape Town, to conduct an investigation into the applicability of mathematical hydrodynamic reservoir models for water quality management of stratified water bodies in South Africa.

The report (WRC Report no 304/1/93) by the researchers AHM Görgens, AJ Bath, A Venter, K de Smidt and GvR Marais, is available free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. Please note that overseas orders will be charged a list price of US$ 30.

As South Africa's surface water is becoming more fully utilised, it is increasingly important to have techniques available to manage the surface water resources optimally. The ability to predict the stratification that commonly develops in many reservoirs, has many applications e.g.

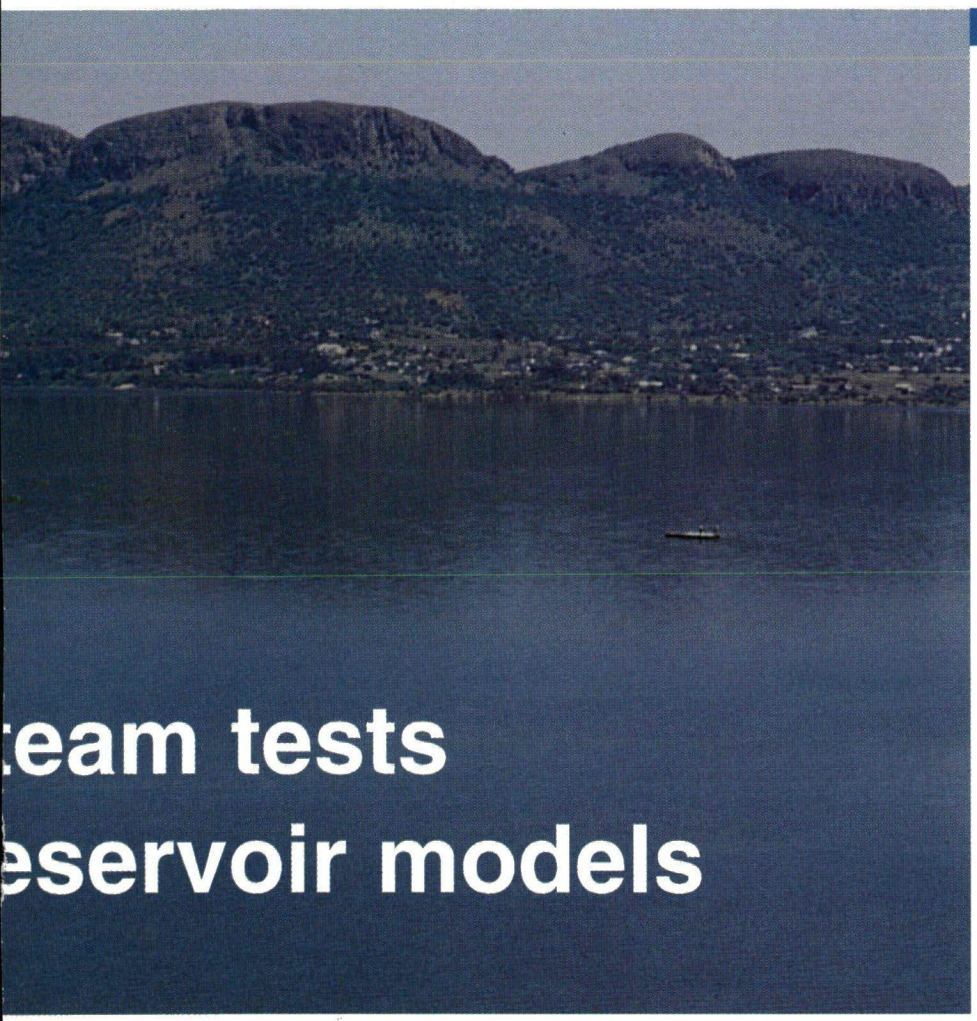
- ❑ salinity management through saline layer scouring, timing of freshwater imports, timing of releases and choice of withdrawal levels,
- ❑ predicting the fate of nutrients or contaminant pathways in a reservoir, be it from a point source input or one of the arms of a multiple inflow reservoir, as well as
- ❑ evaluating the effects of different reservoir destratification techniques to manage e.g. eutrophication,
- ❑ the optimal siting of upstream tunnel inlets or pump stations, and
- ❑ to evaluate the mixing conditions in oxidation ponds.

This research project proposed to evaluate existing mathematical models for their ability to predict stratification and related processes for South African impoundments, and to adapt the models as required and demonstrate their application value for South African impoundments.

MODELS

Four hydrodynamic reservoir models were selected for investigation, namely:

- ❑ **DYRESM** - a one-dimensional model developed at the University of Western Australia
- ❑ **MINLAKE** - a one-dimensional model developed at the University of Minnesota
- ❑ **CE-QUAL-W2** - a multi-dimensional model developed by the Corps of Engineers in the USA
- ❑ **WASP4** - a multi-dimensional model developed by the US Environmental Research Laboratory in Athens, Georgia.



eam tests eservoir models

SOFTWARE

The relevant software, as well as supporting documentation, were obtained directly from the custodians of the respective models. All four models required various degrees of modification to suit local needs. A great deal of supporting software development took place to enhance both the input and output side of the particular models, with a strong accent on computer screen graphic.

In a number of instances modifications and improvements were required to individual process formulations in the model software. Through these activities the available models were made more user friendly, adapted for application to local conditions and also evaluated in terms of their relative strengths and weaknesses for local applications.

MODEL - DATA REQUIREMENTS

In line with their mechanistic nature, the type of reservoir models under discussion typically require daily hydrometeorological data as input data to characterise the driving forces acting on the impoundment. Usually a certain number of water quality depth profiles, from the same period as the hydrometeorological time-series are also required in in order to calibrate or verify the models. Certain physical and water quality process representations in the models are typically augmented by coefficients or parameters of a site specific nature. Calibration refers to the trial and error process by which values for such coefficients or parameters are determined by comparing simulated and observed water quality depth profiles. Modelling spatial resolution can be either uni- or multi-dimensional.

Typical input data required are as follows:

- ❑ mean daily wind-speed
- ❑ daily shortwave radiation
- ❑ daily longwave radiation
- ❑ daily sunlight hours
- ❑ mean daily air temperature
- ❑ daily rainfall
- ❑ mean daily relative humidity or vapour pressure
- ❑ daily inflow volume
- ❑ daily abstraction (or release) volume
- ❑ daily inflow water quality concentration
- ❑ physical dimensions of dam wall and dam basin
- ❑ physical dimensions of outlet (or spill) configuration
- ❑ physical dimensions of inflowing stream channels.

For application purposes, the models were matched to reservoirs both in terms of their particular data needs and in terms of their appropriateness to deal with a likely water quality management challenge.

DATA BASES

No field work or field gathering of data were intended under this project and all modelling data bases were assembled from existing raw data sources, as listed in the report. Since available data sets were not in a readily useable format it was necessary for the researchers to assemble and finalise appropriate data bases for the study. Ultimately, four reservoirs were selected for inclusion in the study. They were selected for their inherent water quality management challenges and the availability of data as required. The reservoirs were:

- ❑ Roodeplaat Dam on the Pienaars River
- ❑ Inanda Dam on the Mgeni River
- ❑ Vaal Barrage on the Vaal River
- ❑ Hartbeespoort Dam on the Crocodile River

The hydrometeorological databases were found to suffer from a range of inadequacies and extensive use had to be made of data collected at stations remote from the dams. It appeared that the highest requirements for accuracy and representativeness of data lie with daily wind run, daily inflow quantity and quality data.

According to the research team the in-reservoir databases were found to be mostly inadequate with respect to covering observations on a range of water quality variables at desirable frequencies, observations of the chosen variables at a number of representative points across the reservoir basin, and observations of the chosen variables at a suitable number of depths at each observation point.

Three requirements are relevant for the in-reservoir database, which serves to verify a model's adequacy for water quality management, namely:

- observations of a suitable range of water quality variables at weekly to quarterly intervals: at least temperature, electrical conductivity, suspended solids, phosphates, nitrates, algal indices, total dissolved solids, ammonia;
- observations of the chosen variables at a number of representative points across the reservoir basin: at least three points chosen to expose longitudinal variation and to include the main body of water; and
- observation of the chosen variables at a suitable number of depths at each point: at least three depths at each point - one each in the epilimnion, the metalimnion and the hypolimnion.

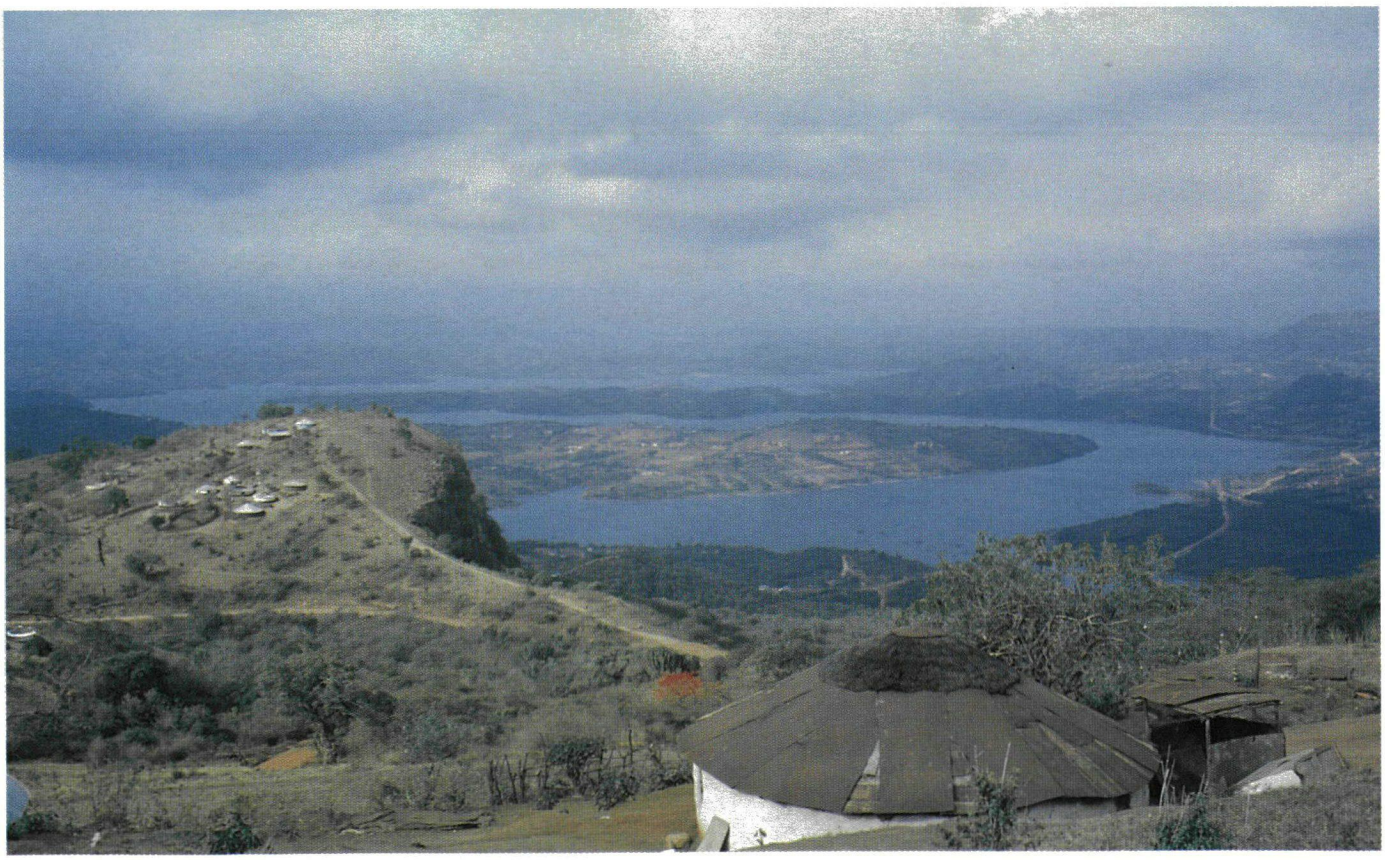
According to the report only the data set for Inanda Dam met all three requirements adequately. However, for the purpose of this project the available data sets of the chosen four water bodies were assembled, filled in and checked for suspect values. The infilling approaches, to deal with periods of missing records or suspect values, are described in the report. These data sets are now available for other studies as well.

RESULTS

The four selected hydrodynamic reservoir models were applied to various degrees in this study:

- DYRESM, a one dimensional model was calibrated and verified for temperature, total dissolved solids (TDS) and hydrodynamics, for Roodeplaat and Hartbeespoort Dams.
- MINLAKE, a one dimensional model, was calibrated for temperature, hydrodynamics and (with mixed success) for suspended solids, phosphates and algae biomass on the Roodeplaat Dam.
- CE-QUAL-W2, a multi-dimensional model, was calibrated and verified (only for Inanda Dam) for temperature, TDS, phosphate, algae biomass, suspended solids, dissolved oxygen and hydrodynamics, for Inanda Dam and the Vaal Barrage.
- WASP4, a multi-dimensional model, was calibrated for hydrodynamics and volume balance on Inanda and Roodeplaat Dams.

The results and recommendations with regard to these four models are discussed comprehensively in the respective model application chapters in the report.



Inanda dam

Vaal Barrage

CASE STUDIES

Apart from the required calibration and verification exercises, limited time allowed only two illustrative water quality management-related case studies, namely, the hypothetical destratification of Roodeplaat Dam and the blending of Vaal Barrage water with low-salinity releases from Vaal Dam. These two illustrative case studies adequately illustrated the potential of the technology.

The technical feasibility of destratification by air bubble plume action, of a typical dam in the summer rainfall zone (Roodeplaat Dam), was demonstrated and broadly quantified with a simulation using DYRESM.

The two-dimensional nature of the translation of the low salinity release water through the Vaal Barrage was demonstrated by a simulation with CE-QUAL-W2. The consequent distribution of non-conservative water quality constituents throughout the Barrage was also highlighted.

CONCLUSION

According to the report the two illustrative case studies adequately demonstrated the potential of the technology. Inspite of a lack of time and money as well as incomplete data bases which restricted the project team's effort.

The research team conceded that the cost and time implications of the comprehensive data requirements of physically-based, time series-driven models (such as those investigated in this project), is often a cause of concern to water resource managers.

However, the research team believes that their case studies on destratification of Roodeplaat Dam and freshening releases into the Vaal Barrage, illustrate the value of this level of modelling. They say that it is unlikely that the detailed findings which such water quality management studies are required to yield, could be achieved with steady-state models or rule-based approaches.

RECOMMENDATION

The researchers recommend that, with regard to reservoirs where intensive water quality management is expected in the future, a monitoring strategy be devised to accomodate the primary input requirements of hydrodynamic models such as those implemented in this project. In particular attention should be given to

- wind data: windspeed (over water) is of major significance in all the selected models,
- in-reservoir profiles: key water quality variables should be given high priority, as well as
- water quality of inflowing streams: daily to weekly measurement of key variables, as noted in the report.

A H M GÖRGENS
A J BATH
A VENTER
K DE SMIDT
G v R MARAIS

THE APPLICABILITY OF HYDRODYNAMIC RESERVOIR MODELS FOR WATER QUALITY MANAGEMENT OF STRATIFIED WATER BODIES IN SOUTH AFRICA

Report to the
WATER RESEARCH COMMISSION
by
NINHAM SHAND INC and the
DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF CAPE TOWN

WRC Report No 304/1/93

Decision support system developed for catchment management based on environmental considerations

The Water Research Commission recently released the results of a study which was aimed at facilitating environmentally sound decision making within the catchment basins of the Letaba and Sabie Rivers in the Eastern Transvaal.

To achieve this aim, the researchers, WF van Riet, JDJ van Rensburg, R Dreyer and S Slabbert, from the Department of Landscape Architecture at the University of Pretoria, linked the integrated environmental management (IEM) procedure with geographic information systems (GIS).

In the final series of reports on the study presented to the Water Research Commission, the researchers say that they are confident that the process followed during the project can be applied to other catchment basin studies. The method of compiling an ecological and social database, evaluating this data according to ecological, development, agricultural and aesthetic values and combining these in a geographic information system can be applied to any other project. The obvious advantages of a digital database is strengthened by the fact that updating is possible for future changes and based on historic data, future predictions can be made with regards to flow rates, land use etc.

AVAILABLE DATA

A detailed database on the Sabie and the Letaba Rivers is available in ARC/INFO format. The data is stored on a series of 1,4 Mb disks and are available from the GisLAB at the University of Pretoria as well as from the Computing Centre for Water Research (CCWR) in Pietermaritzburg.

The researchers say map printouts are possible through GIS from original coverages or pre-compiled maps are available when data is viewed through ARCVIEW.

Anyone interested in obtaining data in electronic form can contact the GisLab at telephone (012) 342-2376.

REPORTS

The following reports on the project are also available and can be ordered free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (The overseas price is shown in brackets.)

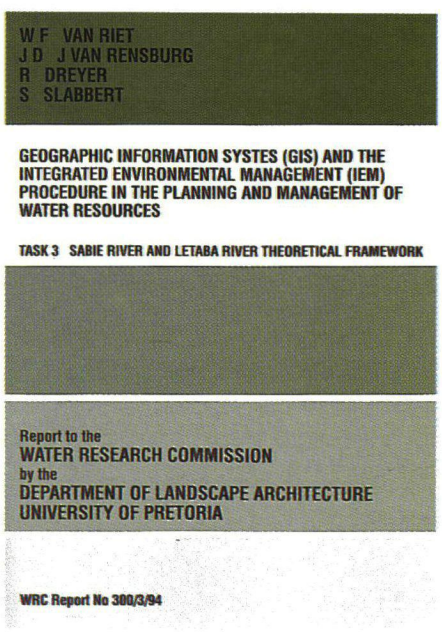
❑ **Geographic Information Systems (GIS) and the Integrated Environmental Management (IEM) procedure in the planning and management of water resources - Executive Summary.** (WRC report 300/1/94) (Free of charge).

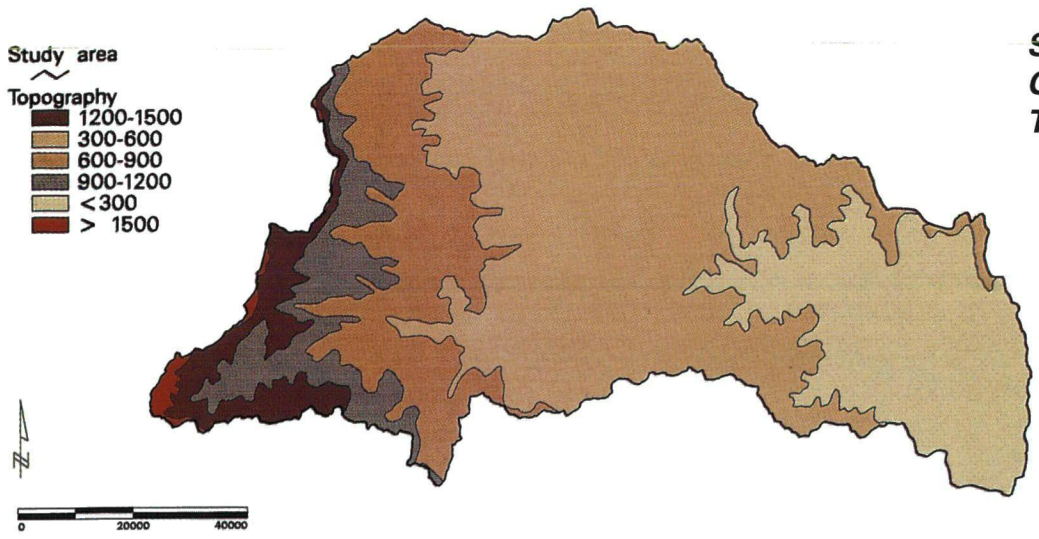
❑ **GIS and hydrological modelling.** (WRC report 300/2/94) ($10).

❑ **Sabie River and Letaba River theoretical framework.** (WRC report 300/3/94) ($20).

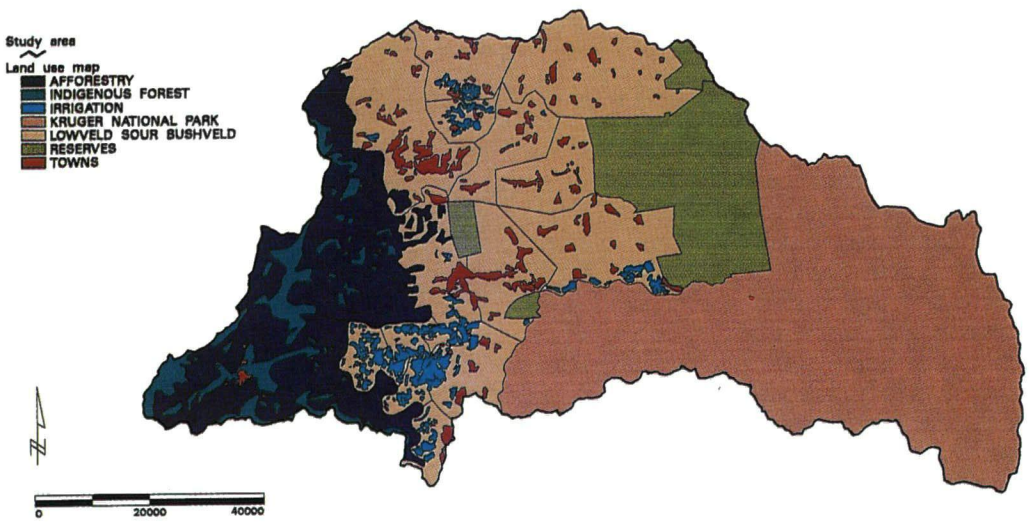
❑ **Environmental atlas for the Sabie River catchment.** (WRC report 300/4/94) ($10).

❑ **Environmental atlas for the Letaba River catchment.** (WRC report 300/5/94) ($10).





SABIE RIVER CATCHMENT TOPOGRAPHY



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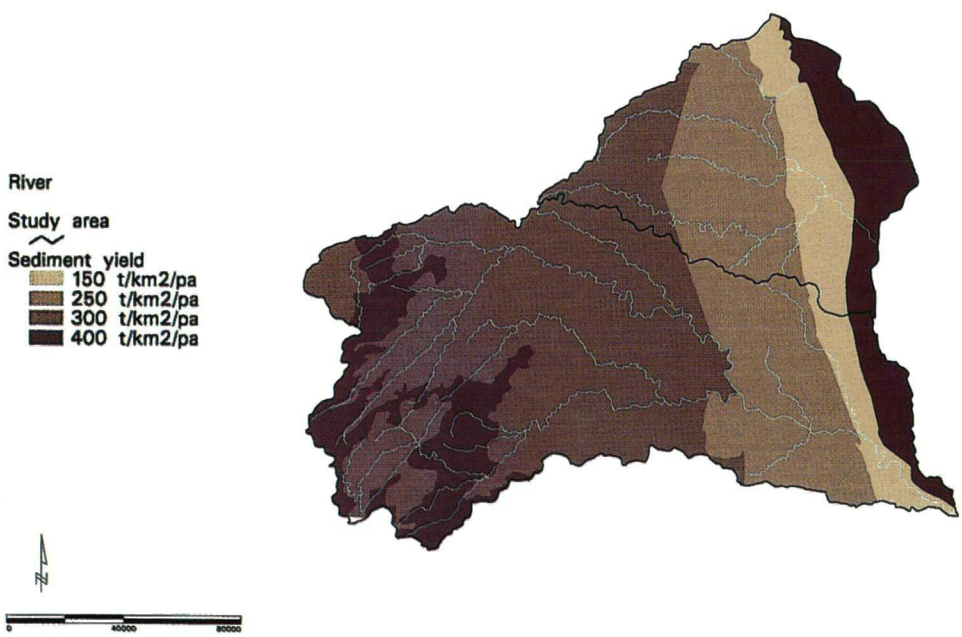


LETABA RIVER CATCHMENT RUNOFF

New formulas will help irrigators to improve agricultural water management

All persons and organisations interested in managing agricultural water use should be encouraged to use climate corrected evaporation coefficients when planning irrigation scheduling, say two researchers from the Department of Agrometeorology at the University of the Orange Free State.

The researchers, WH van Zyl and JM de Jager, say in the past many problems have been experienced with the use of crop evaporation coefficients, mainly because of the inability of most techniques to separate vegetation evaporation from soil evaporation.

In a study financed by the Water Research Commission (WRC) a new definition of atmospheric evaporative demand is used which accommodates both vegetation evaporation and soil surface evaporation. The theory in this study furthermore recognises a vegetation evaporation coefficient as well as a soil evaporation coefficient.

The researchers say these concepts were considered and the necessary equations for computing vegetation and soil evaporation from vegetation and soil evaporation coefficients were formulated, applied and analysed.

According to the researchers the other major cause for concern regarding the traditional crop evaporation coefficients stems from the climatic dependence of evaporation coefficients.

The objective of the WRC sponsored study was therefore to identify the major weather elements influencing the crop evaporation coefficient and produce a theory whereby a crop evaporation coefficient, corrected for climate, may be calculated.

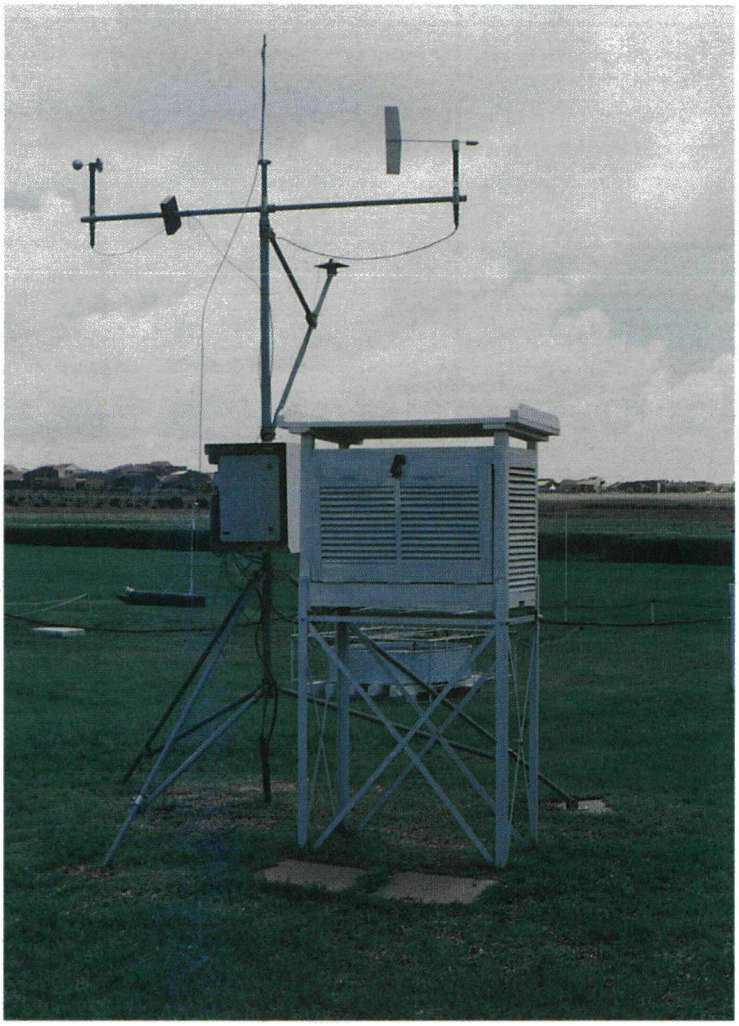
The techniques developed in the study have noteworthy implications for the accurate calculation of reference crop evaporation, atmospheric evaporative demand, evaporation coefficients and effective crop water consumption. Their application will increase water use efficiency and hence bring about considerable savings in South Africa's most scarce commodity - water.

Copies of the final report summarising the results of the research project called "Research on the climatic dependence of evaporation coefficients" (WRC report 260/1/94) are now available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: $25.)

Atmospheric evaporative demand is defined as the upper limit of evaporation from a natural vegetative surface of which the water content of the soil surface layer is at its current value. Atmospheric evaporative demand represents the sum of evaporation from vegetative and soil surfaces of a natural terrestrial surface. It is calculated as the product of evaporation coefficient and reference crop evaporation and is invaluable for estimating the upper limit of crop water requirements. From this the daily soil water content in cropped lands may be computed. Such information is used extensively in practical problem solving, for example, by applying the PUTU-system of crop growth models.

The accuracy of atmospheric evaporative demand estimated in the manner described here, however, depends entirely upon the reliability of the evaporation coefficient and the accuracy with which the reference crop evaporation is calculated or measured. Inaccuracies in the evaporation coefficient values cause insufficient or over-irrigation with detrimental financial implications, not only to individual farmers, but for the country in general.

Furthermore, while reference crop evaporation may accurately be estimated from the Penman-Monteith equation, uncertainty as to the extent of the climatic dependence of the evaporation coefficient exists. The study of these problems forms the major thrust of this report.



A weather station. Crop water requirements can easily be calculated from automatic weather station data and the tables produced in the WRC report.

OBJECTIVE

The overall objective of the research project was to:

- Determine in what manner the crop coefficients of onion, potato and wheat are influenced by climate;
- Determine theoretical and experimental values of crop coefficients for the mentioned crops for relevant regions in South Africa having similar climate; and
- Determine the agreement between experimental and theoretical evaluations of crop coefficients.

The report says that as the project progressed, the need to include a summer crop became evident and the project evaluation committee recommended that wheat be replaced by maize. The inclusion of maize, however, eliminated the study on onion as the latter part of the growth season of this crop coincides with that of maize.

The specific objectives of the study were:

- To evaluate hourly mean and daylight mean evaporation coefficients;
- To investigate their behaviour throughout the crop growing season;
- To relate the hourly mean and daylight mean evaporation coefficients to the weather elements, solar radiation, ambient air temperature, wind speed and water vapour pressure, and
- To determine monthly mean evaporation coefficients for different localities throughout South Africa for potato and maize crops.

RESULTS

- **Measurement of reference crop evaporation**

The reliability of five micro-meteorological techniques for measuring reference crop evaporation were examined. Values of reference crop evaporation obtained using the different techniques were compared against reference crop evaporation measured lysimetrically.

- The Bowen ratio underestimated daylight reference crop evaporation by 25 per cent. The discrepancies occurred especially at relatively high evaporation rates. The slope through the origin and the correlation coefficient were 0,75 and 0,88 respectively.
- The energy budget and infra-red thermometer technique overestimated daylight reference crop evaporation by approximately 24 per cent. The slope through the origin and correlation coefficient were 1,24 and 0,92 respectively.

- The Penman-Monteith estimates compared excellently with measured reference crop evaporation. Comparisons yielded a slope through the origin of 0,96 and a correlation coefficient of 0,94.

- The energy budget equation and eddy correlation sensible heat method overestimated daylight reference crop evaporation by 8 per cent. The slope through the origin and correlation coefficient was 0,92 and 0,52 respectively. Eddy correlation measurements were made at a height of 2 m above grass level. Corresponding values for hourly measurements made at 0,25 m above grass level were 0,84 and 0,87 respectively.

Direct eddy correlation determinations of reference crop evaporation made at 2 m height yielded a slope through the origin and correlation coefficient of 0,51 and 0,75 respectively for the daylight period. Hourly comparisons at a height of 0,25 m above grass level yielded values of 1,08 and 0,79 respectively these same statistical parameters.

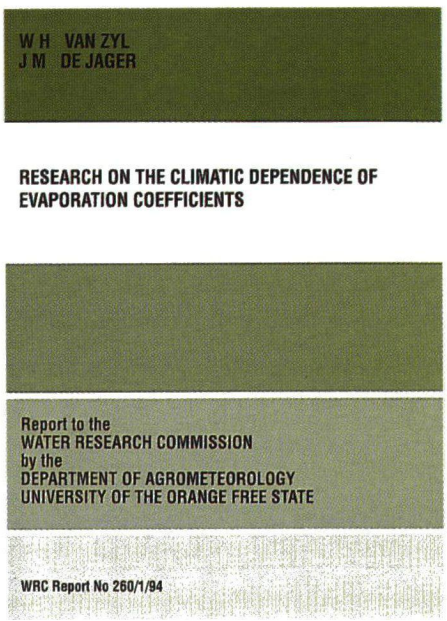
❑ Measurement of atmospheric evaporative demand

Atmospheric evaporative demand for the maize crop was determined using the energy budget and eddy correlation sensible heat technique. When compared to lysimeter measurements this technique yielded a slope through the origin and correlation coefficient of 0,76 and 0,83 respectively on 317 hourly values. Corresponding values obtained using the direct eddy correlation method were 1,10 and 0,75 respectively.

Based upon these results, it was decided to rely upon weather data and the Penman-Monteith equation and both the 10 m^2 lysimeter and the energy budget and eddy correlation sensible heat methods when determining crop evaporation coefficients for maize. The Penman-Monteith equation and the results obtained from the 10 m^2 lysimeter planted to potatoes were used when determining crop evaporation coefficients in the case of potatoes. For both crops, the mentioned methods had proved to be acceptably accurate.

❑ Micro-meteorological determination of the climatic dependence of upper limit vegetation evaporation coefficients.

The theory developed by the researchers stipulates that the climatic dependence of crop evaporation coefficients manifests itself in the variation in the upper limit vegetation evaporation coefficient. For this reason, multiple regression analysis was used to develop relationships between hourly or daytime means of the upper limit vegetation evaporation coefficient, and hourly or daylight means of the weather elements.



The regressions yielded high coefficients of determination of 0,87 for both mature potato and maize crops. During early growth stages, for canopies with incomplete vegetative cover, the coefficients of determination were 0,99 and 0,74 for potatoes and maize respectively. These high regression coefficient values, however, are to a large extent due to the rapid increase with time in the fractional radiation interception. The resultant regression expression for the upper limit vegetation evaporation coefficient in terms of climate for incomplete vegetation cover, should therefore at this stage be deemed to be preliminary, the report says.

For the hourly multiple regression analysis the corresponding regression coefficient values were 0,39 and 0,21 for potatoes in the early and late season respectively. Values for maize were 0,29 and 0,46 respectively.

❑ Macro-meteorological determination of the influence of climate on upper limit vegetation evaporation coefficients.

Macro-scale weather was measured using an automatic weather station. The elements measured included solar radiation flux density, air temperature, wind speed and water vapour. Multiple regression analysis of the upper limit vegetation evaporation coefficient on values of macro-daytime mean values of the weather elements, yielded coefficients of determination of 0,73 and 0,70 for mature potatoes and maize respectively.

Two equations for computing the upper limit vegetation evaporation coefficient for late season potatoes and maize (i.e.mature crops) are given in the WRC report.

❑ Values of evaporation coefficients for potato and maize crops for different localities in South Africa.

Monthly mean upper limit vegetation evaporation coefficient values for an established potato crop were computed for different localities (i.e. climates) in South Africa. They vary between 1,51 and 1,01 and are presented in tabular form. The corresponding range for a maize crop was found to be 1,56 and 0,89.

The simple set of tables included in the final report makes it possible to easily apply the results in practice.

CONCLUSION

Summarising the research results, the report states that evaporation coefficients relevant to the full cover stages of potato and maize crops can now be computed by using the mathematical relationships and the calculation tables contained in the report. From these, crop water requirements may rapidly be calculated using automatic weather station data. For other crops, structurally similar to potatoes and maize, the same relationships developed could be used as a first approximation.

NEW DATABASE: CALLING ALL EXPERTS...

The South African Water Information Centre is in the process of building a database of water-related sources of information. The aim of the project is to identify key areas of expertise and information such as databases, bulletin boards, etc and list them on one central database. This will allow the searcher easy access to a list of useful sources, along with contact names and addresses. The database will be administered by SAWIC and will initially be searched by the SAWIC staff. However, the eventual aim is to make it widely available to enable interested parties to search for their own information.

The format in which the data will be displayed is shown below, using the WATERLIT database as an example. The keywords are used to identify specific areas of information covered by each source and to make the database easily searchable. Any additional details relevant to the data source are included in the section headed 'Notes'.

If any of the readers are experts in their fields and are willing to answer queries, or are able to supply information or contacts for the Water Information Sources Database, they are invited to fill in the blank form and send it to:

Leigh Fraser
South African Water Information Centre
P O Box 395
0001 PRETORIA
Telephone: (012) 841-3149.
Fax: (012) 86-2869.

RefNo : **11** **Type:** **DATABASE**
Update : **29/11/1994** **Language:** **English**

* **WATER LITERATURE**

** **WATERLIT**

Producer : **SOUTH AFRICAN WATER INFORMATION CENTRE**
Contact : **Angela Rethman** **Position:** **Project Manager**
PostAdd : **PO Box 395**

Town : **Pretoria**
Code : **0001** **Country:** **SOUTH AFRICA**

StrAdd : **CSIR, Meiring Naude Ave**

Town : **Pretoria**
Code : **0002** **Country:** **SOUTH AFRICA**
Tel : **(012) 841 2048** **Fax:** **(012) 862 869**

Keyword : **water supply; water treatment; water quality; hydrology; irrigation; groundwater; water pollution control; wasteater treatment; sanitation; industrial wastes; waste management; environmental issues; legislation**

Notes : **The right information can be traced within minutes on the WATERLIT database. Ask the specialists at the South African Water Information Centre, or search the data base yourself from a CD-ROM, or a menu-driven online system.**

* **Full name of source/service**

** **Acronym of source/service**

WHEN THE RAINS STAY AWAY: A CASE FOR A DROUGHT RESEARCH INSTITUTE

"The distribution of food is a lot faster than teaching people how to grow it"
David C Korten (1980)

Drought, more than any other natural phenomenon, will affect the future of the African continent and will influence long-term development and disaster policies of nations and whole regions. We know that within the Southern African Development Community - Environmental land management sector (SADC-Elms) programme, regional approaches to drought management have high interest. We also know that our esteemed colleague Ms Joan Whitmore, a past director of the former Hydrological Research Institute (HRI) is promoting the idea of establishing a Drought Research Institute (DRI) in South Africa. We have collected some of her thoughts for discussion as we do agree with her feeling that South Africa is probably ready to take the lead in Africa in agroclimatological and agrohydrological research.

Drought is virtually endemic in southern Africa - as it is in most mid-latitudinal countries - yet many people still regard it with surprise and dismay each time it recurs. This unenlightened attitude has serious consequences, in that

- it implies that drought invariably is unpredictable, uncontrollable and exceptional, as a result of which
- it is apt to engender passivity, unpreparedness and reliance on bailing out, rather than self-reliance.

Blame does not rest solely on those who hold such views but also on those whose responsibility it is to gather and disseminate knowledge on the causes and nature of droughts, and above all, on strategies for lessening the impact of drought.

We need more imaginative, innovative thinking and bold action on land- and water management strategies.

Year after year, almost without exception, drought hits some part of southern Africa.

While it is not yet possible to predict the real-time onset, duration, extent and severity of a particular drought, the susceptibility of a region to drought - that is, the likelihood of droughts of varying severity - can certainly be assessed in probabilistic terms by intensity/ duration/frequency analyses and other statistical means including geographical distributions.

It also is not correct to regard the recurrence of severe droughts as a symptom of climatic change. History is full of examples where droughts have caused major social upheavals or lead to the disappearance of entire civilisations.

Until the concept of establishing a Drought Research Institute has been accepted, it is premature to elaborate on the facilities that such an Institute should provide. Suffice it to say at this stage that Ms Whitmore envisages the DRI as comprising, inter alia:

- dryland and irrigated plots for field experiments,
- facilities for the introduction, selection and breeding of drought resistant plants,
- glasshouses and temperature/humidity controlled chambers for pot and trench experiments,
- plant and animal laboratories,
- a soil laboratory,
- camps for stocking rate and rotational grazing experiments,
- space and equipment for experiments on land-shaping, artificial recharge of boreholes, run-off harvesting techniques, reduction of vapour losses, moisture recovery from air and soil, and so on,
- computer facilities for statistical analyses and simulation modelling, especially of climatological aspects of drought,
- a drought information centre with facilities for collecting, storing and retrieving information, and disseminating it on optical discs, microfiche, audio-visually, in printed form, or in other ways.

Ms Whitmore got considerable interest for her proposal but very little in terms of any initiative or commitment, both here and internationally. We feel that some-

thing like this has to grow and requires more widely expressed needs. On the other hand, the right contacts may sometimes precipitate actions in which we scientists only need to fill the gaps to keep the initiative going. Whatever the "right" approach, we suggested another way to focus on droughts in southern Africa, namely through a multi-disciplinary conference on drought. Our first thoughts with "multi-disciplinary", are:

Hydrology
the full spectrum;

Agriculture
management of plant/water regime, holistic farming, small farming systems;

Water resources
water allocation, demand management, catchment management, appropriate technology;

Socio-economics
drought aid, demography;

Meteorology
drought characteristics, prediction;

Information systems
data collection, transmission, decision-support, extension

Some of the linkages on which one could build are:

- ❑ State drought policy in the RSA;
- ❑ IAHS, IHP and WMO who are all interested to see South Africa play a greater role; Negotiations with WMO on data transmission via satellite are underway;
- ❑ SARCCUS, an organization in which agriculture and water both come together through the overall soil conservation objective;
- ❑ SADC which is considering regional management of natural resources;
- ❑ The Global Climate Change programmes;
- ❑ African drought study programmes through international donors;
- ❑ International drought studies through the Drought Network News.

This is obviously not the normal hydrology conference but one to bridge discipline gaps, identify common ground and major knowledge gaps and reach decision-makers with new policy-thinking.

We would like to receive your comments to see whether the ideas of an DRI and/or drought conference have merit and to build up to a good discussion in this column.

Please direct your comments to:

The SANCIAHS Secretary
c/o Water Research Commission
PO Box 824
PRETORIA
0001

Fax: (012) 311-2565
Email: Hugo@WRC.CCWR.AC.ZA

Eberhard Braune
Hugo Maaren

Waste site assesment: workshops planned

A series of half day workshops are being planned for February 1995 in which the new WASP method for groundwater impact assessment at waste sites will be discussed.

Groundwater resources are often at greatest risk from waste disposal activities, because they are not visible or easily understood. For this reason the Water Research Commission decided to fund a research project into the development of a methodology suitable for South African conditions, which aids in deciding whether a waste site is suitable in terms of its potential impact on groundwater resources.

The project was carried out by Roger Parsons of the Division of Water Technology (CSIR) and Jeff Jolly currently from Groundwater Consulting Services.

Initially the researchers investigated all known methods used world-wide to assess waste site suitability and a system applicable to South African conditions evolved from the existing methods. The system assesses the threat and risk of groundwater resources being polluted by a waste site, ultimately ending with an evaluation of the suitability of the site. The method adheres to the principle that waste and aquifers must be separated - WASP (Waste - Aquifer Separation Principle).

The project has now been completed and the Water Research Commission would like the results of the investigation to reach as wide an audience as possible. A series of half day workshops will therefore be held in February 1995 to explain the method and the WASP principle to all interested parties. The workshops are planned to take place throughout the country as follows:

- ❑ Cape Town – 15 February 1995
- ❑ Port Elizabeth – 20 February 1995
- ❑ Bloemfontein – 21 February 1995
- ❑ Johannesburg – 22 February 1995
- ❑ Pretoria – 23 February 1995
- ❑ Durban – 24 February 1995

Cost for the workshop will be R100 which will include the manuals and computer program plus snacks and drinks after the workshop. The workshops will be restricted to the first 25 applicants per venue. Anyone wishing to attend a workshop, please contact Jeff Jolly at Groundwater Consulting Services in Cape Town (tel (012) 794-7997 or fax (012) 794-2823) for further details.

SA WATERKALENDER

The Water Research Commission is placing this calender in order to assist with the co-ordinating of water events in South Africa.

You are invited to send information about conferences, symposia or workshops to the SA Waterbulletin.

Address:
The Editor,
SA Waterbulletin,
P.O. Box 824,
0001 Pretoria
Tel (012) 330-0340
Fax (012) 331-2565

Legend:

- ❍ An SA Water Event arranged for these dates.
- ❑ 2nd SA Water Event scheduled for these dates.
- ✗ 3rd SA Water Event scheduled for these dates.

See conferences and symposia pages for events.

Die Waternavorsingskommissie plaas hierdie kalender om te help met die koördinering van watergebeurtenisse in Suid-Afrika.

Alle belanghebbendes word uitgenooi om inligting aan SA Waterbulletin te stuur.

Adres:
Die Redakteur
Posbus 824
0001 Pretoria
Tel: (012) 330-0340
Fax: (012) 331-2565

Gids:

- ❍ Een SA Watergeleentheid vir hierdie dae.
- ❑ 'n Tweede SA Watergeleentheid gereël vir dié datums.
- ✗ 'n Derde SA Watergeleentheid gereël vir dié datums.

Sien Konferensies-en Simposiumbladsy vir aangeduide geleenthede.

1995

JANUARY 1995

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SOUTHERN AFRICA 1995

WATER MICROBIOLOGY
FEBRUARY 14 - 17

Introductory course. For more information contact Gerrit Idema at Water Technology, CSIR. Tel (012) 841-3948. Fax (012) 841-4785.

WASTE SITE ASSESSMENT
FEBRUARY 15 - 24

A series of half day workshops are planned to take place throughout South Africa. See announcement on page 27.

GROUNDWATER MODELLING
FEBRUARY 27 - MARCH 3

The Institute for Groundwater Studies presents a short course in groundwater modelling. See advertisement on page 2.

GROUNDWATER
APRIL 3 - 7

The Centennial Conference of the Geological Society of South Africa will be held in Johannesburg. See announcement on page 30. Enquiries: Tel & Fax (012) 47 3398.

SAICE
APRIL 11 - 13

The 1995 SAICE congress will be held in Port Elizabeth at the historic Feather Market Centre. Enquiries: Adriaan van Eeden at telephone (041) 55-8741 or write to the Organising Committee, PO Box 23903, Port Elizabeth 6000.

BESPROEIING
MEI 10 - 12

Die tweejaarlikse kongres van die Suid-Afrikaanse Besproeiingsinstituut sal in Port Elizabeth gehou word. Sien advertensie op bladsy 32.

RIVER MANAGEMENT
MAY 14 - 19 1995

The IAWQ conference on river basin management for sustainable development will be held in the Kruger National Park.
Enquiries: Dr Ben van Vliet, Watertech, CSIR. Tel (012) 841-2237 Fax (012) 841-4785.

RESOURCE MODELLING
JULY 5 - 10

The '95 world conference on natural resource modelling will be held at the University of Natal in Pietermaritzburg.
Enquiries: Professor John Hearne, Department of Applied Mathematics, University of Natal, Private Bag X01, Pietermaritzburg 3209. Fax: (0331) 260 5599 Tel: (0331) 260 5626.

HYDROLOGY
SEPTEMBER 4 - 6

The 7th national southern African hydrological symposium will be held in Grahamstown.
Enquiries: Prof Denis Hughes, Institute for Water Research, Rhodes University, Grahamstown 6140. Tel (0461) 24014 Fax (0461) 25049. E-mail: Denis @ iwr.ru.ac.za.

IWSA
SEPTEMBER 9 - 15

The 20th biennial congress and exhibition of IWSA will be held in Durban.
Enquiries: Mrs Ginny Eslick, IWSA Congress International, 18 Rapson Road, Morningside, Durban 4001. Tel (031) 233 494. Fax (031) 232 405.

GROUNDWATER
SEPTEMBER 25 - 27

A conference and exposition on groundwater recharge and rural water supply - Groundwater '95 - will be held at the Volkswagen Conference Centre in Midrand.
Enquiries: Conference Co-ordinator, Groundwater Division, GSSA, PO Box 75728, Lynnwood Ridge 0040. See page 31 of this Bulletin

OVERSEAS 1995

WASTE MANAGEMENT
FEBRUARY 1995

The third conference on appropriate waste management technologies for developing countries will be held in Nagpur, India
Enquiries: Professor P Khanna, Indian Association for Environmental Management, NEERI, Nehru Marg, Nagpur 440020, India.

WATER RESOURCES
MARCH 12 - 16

A symposium on water resources management in arid countries will be held in Muscat, Oman.
Enquiries: Acting Director General, Water Resources Management, Ministry of Water Resources, PO Box 2575, Ruwi 112 Oman.

HYDRO-SCIENCE
MARCH 22 - 26

The second international conference on hydro-science and engineering will be held Beijing, People's Republic of China.
Enquiries: Mr Tan Ying, ICHE '95, IRTCES, PO Box 336, Beijing 100044, People's Republic of China.

MEMBRANES
MARCH 27 - 29

A workshop with the theme "Membranes in drinking water production" will be held in Paris, France.
Enquiries: Edith Weitz, Compagnie Général des Eaux, Quartier Valmy, 32 Place Ronde, CEDEX 82 92982 - Paris la Défense. Fax: (331) 46 353150.

AWWA
APRIL 2 - 6

The Australian Water and Wastewater Association's 16th Federal Convention will be held in the Convention Centre at Darling Harbour, Sydney, Australia.
Enquiries: The Secretariat, PO Box 388, Artarmon, NSW 2064, Australia. Tel +61 2 413 1288. Fax +61 2 413 1047.

MICRO-IRRIGATION
APRIL 2 - 6

An international congress entitled "Micro-irrigation for a changing world: conserving resources; preserving the environment" will be held in Orlando, Florida, USA.
Enquiries: Allen Samajstria, University of Florida, Agr. Eng. Department, Gainesville FL 32611, USA. Tel (904) 392-9295. Fax (904) 392-4092.

WATER TREATMENT
MAY 15 - 17

An IWSA specialised conference on advanced water treatment and integrated water system management into the 21st century will be held in Osaka, Japan.
Enquiries: Water Osaka '95, c/o Osaka Municipal Water Works Bureau, 6-28 Minami-ogimachi, Kita-ku, Osaka 530, Japan. Tel 06 (363) 7301. Fax 06 (363) 7362.

GROUNDWATER QUALITY
MAY 15 - 18

An international conference on groundwater quality: remediation and protection (GQ 95) will be held in Prague, Czech Republic.
Enquiries: Conference Secretariat GQ 95, c/o Guarant, Opletalova 15, 110 00 Prague 1, Czech Republic. Tel +42 2 2421 0650 or 2421 0735 Fax +42 2 260 130.

OZONE
MAY 15 - 19

The 12th Ozone World congress will be held in Lille, France.
Enquiries: Mme Michele Rizet, IOA International Coordinator, c/o Societe des Eaux du Nord, 217 blvd. de la Liberte Lille, B.P. 329, 59020 Lille CEDEX, France. Tel 33-2049 4000. Fax 33-2049 4052.

COASTAL ENVIRONMENT
JUNE 13 - 15

The Black Sea regional conference on "Environment protection technologies for coastal areas" will be held at the International House of Scientists, St Constantine Resort in Varna, Bulgaria.
Enquiries: IAWQ - Bulgarian National Committee, c/o USB - Mrs TS Angelova, Oborishte St 35, Sofia 1504, Bulgaria. Tel (+359-2) 43 01 28, 44 11 57. Fax (+359-2) 44 15 90.

ENVITEC
JUNE 19 - 23

The international trade fair for Environmental Protection and Waste Management Technologies will be held in Düsseldorf, Germany.
Enquiries: Messe Düsseldorf, Postfach 10 10 06, D-40001 Düsseldorf. Tel (0211) 45 6001. Fax: (0211) 45 60668.

RAINWATER
JUNE 19 - 25

The 7th international conference of the International Rainwater Catchment Systems Association will be held in Beijing, China.
Enquiries: Dr Mou Haisheng, Dept of Hydrology, Institute of Geography, CAS, Building 917, Datun Road, Anwai, Beijing 100101, PR China. Tel (86) 1 4914289. Fax (86) 1 4911844.

CONTAMINANTS IN WATER
JUNE 29 - 30

A conference on hazard assessment and control of environmental contaminants in water will be held in Copenhagen, Denmark.
Enquiries: Dr Niels Nyholm, Laboratory of Environmental Sciences and Ecology, Building 224, Technical University of Denmark, DK-2800 Lyngby, Denmark.

POLLUTION EVENTS
JULY 24 - 26

An inter-disciplinary symposium on uncertainty, risk and transient pollution events - Acute Risk to the Aquatic Environment will be held in Exeter, UK.
Enquiries: Dr JD Boyle, School of Engineering, University of Exeter, North Park Road, Exeter EX4 4QF, UK.

DIFFUSE POLLUTION
AUGUST 14 - 18

A symposium on diffuse (non-point) pollution will be held in Prague, Czech Republic.
Enquiries: Ing Vladimir Chour, Hydroprojekt AS, Taborska 31, CZ 140 43 Praha 4, Czech Republic.

SEWER SOLIDS
SEPTEMBER 6 - 8

A seminar on sewer solids - characteristics, movements, effects and control will be held in Dundee, Scotland, UK.
Enquiries: Maureen Golden, WWTC, University of Abertay Dundee, Bell St, Dundee, DD1 1HG, UK.

WATER MANAGEMENT
SEPTEMBER 26 - 30

A symposium on integrated water management in urban areas will be held in Lund, Sweden.
Enquiries: Dr Janusz Niemczynowicz, Dept of Water Resources Engineering, University of Lund, PO Box 118, S-221 00 Lund, Sweden.

WASTEWATER RECLAMATION
OCTOBER 17 - 20

The 2nd international symposium on wastewater reclamation and reuse will be held in Iraklio, Crete, Greece.
Enquiries: Mrs T Furnaraki, Municipal Enterprise for Water Supply and Sewerage of Iraklio, 1 Vironos Str., 71202 Iraklio, Greece. Tel: +30-81-229913, 225833 Fax: +30-81-22 9991

WEFTEC '95
OCTOBER 21 - 25

The Water Environment Federation's 68th annual conference and exposition will be held in Miami Beach, Florida, USA. Call for papers. Deadline for submissions December 16, 1994.
Enquiries: Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994 USA. Fax 1-908-885-6417.

LAKE MANAGEMENT
OCTOBER 23 - 27

The 6th international conference on the conservation and management of lakes will be held in Tsukuba and Tsuchiura, Japan.
Enquiries: The Secretariat, Kasumigaura '95, 1-5-38 Sannnomaru, Mito, Ibaraki 310, Japan. Tel +81-292-24-6905 Fax +81-292-33-2351.

WASTEWATER PLANTS
OCTOBER 30 - NOVEMBER 1

The 3rd international specialised conference on design and operation of small wastewater treatment plants will be held in Kuala Lumpur, Malaysia.
Enquiries: Mrs Lorraine Meiring, Water Research Commission, PO Box 824, Pretoria 0001. Tel (012) 330-0340. Fax (012) 331-2565.

CENTENNIAL GEOCONGRESS

South Africa - Land of Geological Superlatives

JOHANNESBURG 3 - 7 APRIL 1995

In celebrating the centenary of the Geological Society of South Africa, which was founded on the 4th of February 1895 at the Chamber of Mines in Johannesburg, this congress will aim to:

- Review the past 100 years of geology in South Africa, Africa and the world in general;
- Expose delegates to the expertise and knowledge of top international experts in the various earth-science disciplines;
- Promote productive professional relationships, joint programmes and the exchange of ideas.
- Offer excursions covering the entire geological record and geographic region of Southern Africa.

Enquiries:
The Congress Organiser, Centennial Geocongress,
PO Box 36815, Menlo Park 0102. Tel/Fax (012) 47 3398.

GROUNDWATER '95

Conference and Exposition on Groundwater Recharge and Rural Water Supply
25 - 27 September 1995
Volkswagen Conference Centre, Midrand

This will be the eighth biennial groundwater conference organised by the Groundwater Division of the Geological Society and the third conference to be organised jointly with the Borehole Water Association of Southern Africa.

Two topics in particular will receive attention during the conference:

AQUIFER RECHARGE

- ❒ Mechanisms and Controls
- ❒ Regional variation
- ❒ Methods for determining recharge

RURAL WATER SUPPLY FROM GROUNDWATER

- ❒ Exploration
- ❒ Appropriate aquifer testing procedures
- ❒ Appropriate abstraction techniques
- ❒ Infrastructure maintenance
- ❒ Management of well fields
- ❒ Social considerations
- ❒ Groundwater vs surface water supplies
- ❒ Aquifer and borehole protection

The programme will also include open sessions on any geohydrological topic or information gained during field investigations or arising from research projects.

TECHNICAL WORKSHOPS

Technical workshops for the groundwater industry, organised by the Borehole Water Association, will be run parallel with the scientific programme sessions.

TECHNICAL EXCURSION

A post-conference technical excursion to view rural water supply schemes is being planned.

COST

Registration will be approximately R750. A reduced fee will be available for members of the Groundwater Division, Borehole Water Association, speakers and bona fide full time students.

A range of accommodation from approximately R110 to R340 per person per night will be available.

ENQUIRIES TO:

Conference Co-ordinator,
Groundwater Division,
PO Box 75728,
Lynnwood Ridge 0040.

Die Suid-Afrikaanse Besproeiingsinstituut kondig met genoeë aan

- 1995 -
TWEEJAARLIKSE SABI KONGRES

10 - 12 Mei 1995

Die Edward Hotel, Port Elizabeth

TEMA

Verantwoordelike ontwikkeling, bestuur en bedryf van besproeiingstelsels.

- ❑ Wat is ons probleme?
- ❑ Het ons die oplossings?
- ❑ Oor die hele spektrum?
- ❑ Hoëtegnologie.

FORMAAT

Dag 1 - Inleiding (middag)

Dag 2 - Beplanninng, ontwerp en produkpromosie (voldag)

Dag 3 - Bestuur, bedryf en opsomming (Oggend)

KOSTE

Registrasie: R250 per persoon
Laat registrasie (na 1 Maart 1995): R400
(Hierdie tariewe mag dalk effens verander.)

Voorlopige akkomodasiekoste by die Edward Hotel (nie verpligtend, maar verkieslik)
Gedeelde kamer: R100 per persoon per dag (ontbyt ingesluit)
Enkelkamer: R160 per persoon per dag (ontbyt ingesluit)

NAVRAE

Die Suid-Afrikaanse Besproeiingsinstituut,
Oos-Kaaptak, Privaatsak X27592,
Greenacres 6057.
Tel (041) 331284.
Faks (041) 331583.