

# S4 waterbulletin

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## RIVERS RESEARCH

Pre-impoundment study of the Sabie-Sand River system

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## WATERGEDRAAGDE SIEKTES

Menslike virusse in wateromgewings ondersoek

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## WATER QUALITY

Reporting on the development of a recirculating artificial stream laboratory

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UNIVERSITEIT

STELLENBOSCH

**SMALL DAMS DESIGN COURSE**

**THIRD RIVER FLOOD  
HYDRAULICS CONFERENCE**

*November 1997 Stellenbosch*

*November 1997 Stellenbosch*

A course on the Design of Small Dams is to be offered at the University of Stellenbosch on 3 and 4 November 1997, under the auspices of SANCOLD. Topics to be covered include: Planning; Water Rights; Yield Analyses; Foundations; Embankment Dams; Concrete, Rollcrete and Masonry Dams; Spillways and Outlet Works; Construction; Maintenance and Operation; Dam Safety; Sedimentation.

The registration fee for the course is R900 (R2 500 for persons attending both the course and the conference).

A limited number of persons will be admitted to the course and the registration fee is required by 1 September 1997.

The 3rd International Conference on River Flood Hydraulics is being organised jointly by HR Wallingford and the University of Stellenbosch from 5 to 7 November 1997. Papers from different parts of the world will be presented on: Flood Hydrology; Flood Hydraulics; Flood Plain Management; Flood Control; River Morphology; Reservoir Sedimentation; Flow Measurement; Environmental Aspects.

The registration fee for the conference is R1 900 for persons from the Rand Monetary Area. (£390 for persons from outside this area, who must register with Ms J Watts, HR Wallingford, Howbery Park, Wallingford, Oxon, OX10 8BA England). The registration fee is required by 1 September 1997.

**For further information and registration please fill in the following form and forward to:**

Prof A Rooseboom, Department of Civil Engineering, University of Stellenbosch, Private Bag X1, MATIELAND, Stellenbosch, 7602  
Telephone: +27 (21) 808-4353, Fax: +27 (21) 808-4361. E-mail: AR2@maties.sun.ac.za

Name: .....

Affiliation: .....

Address: .....

.....

.....

Telephone No: ..... Fax No: .....

*Please supply me with the following information:*

Further information on the Dam Design Course.

Further information on the River Flood Hydraulics Conference.

Information on Accommodation. \*

\* (Accommodation arrangements should be made as early as possible as there is an upsurge in the number of tourists visiting Stellenbosch).

Please indicate:

I will possibly  probably  definitely  be attending the course.

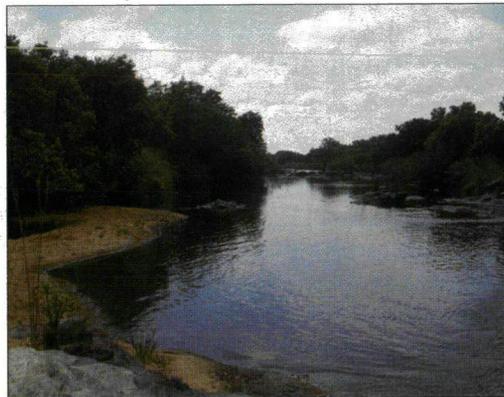
I will possibly  probably  definitely  be attending the conference.

My registration fee\*\* is attached  will be forwarded by 1 September 1997

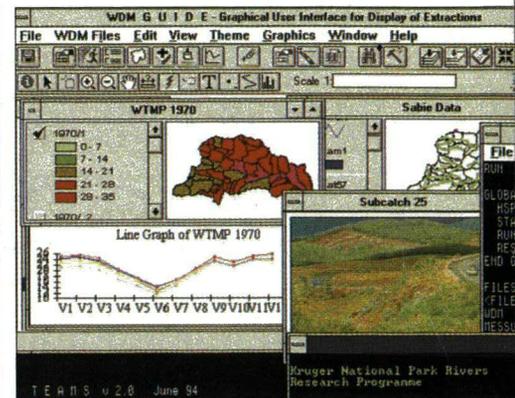
\*\* (Cheques to be made out to the University of Stellenbosch).



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Cover: *The Sabie River flowing through the world renowned Kruger National Park. (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 (E-mail: Jan@wrc.cwr.ac.za). Asst Editor: Helene Joubert (E-mail: Helene@wrc.cwr.ac.za). Ed Secretary: Rina Human (E-mail: Rina@wrc.cwr.ac.za). Layout: Chill Design 082 578-7257. Colour Separations: Montage Repro. Printing: Beria Printers.

# WISA (Western Cape Branch) promotes water awareness

Various water-related activities were organised in the Western Cape during March and April 1997 in an attempt to create public awareness and to focus public attention on one of South Africa's most precious resources. (The photographs have been received from WISA committee member, Dr Bill Ross.)

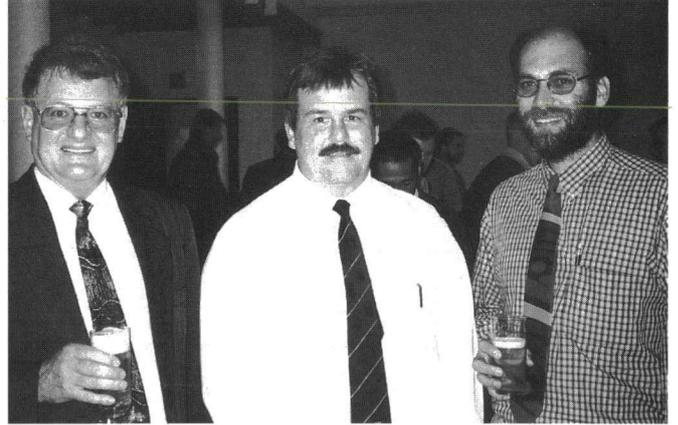
*Right: Mr Henk Beekman (Vice-Chairman: WISA, Western Cape Branch) and Alderman William Bantam (Mayor of the Cape Metropolitan Council) officiated at the prize-giving function of the Water Week competition for all primary schools in the Cape Metropolitan area. The competition was organised by the Fairest Cape Association and sponsored by WISA.*



*A strategic planning "Bosberaad" for the Water Care Technical Division of WISA was held at Montagu Springs. Problem areas in the Division were identified and action plans formulated to resolve such problems.*



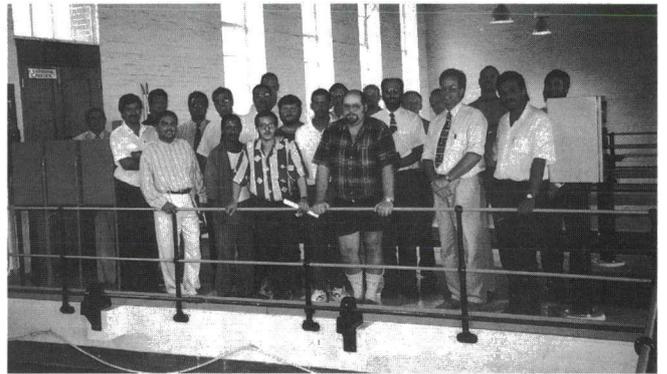
A workshop titled "Waste-water treatment in peri-urban areas" was organised in Langa by the Community Water Supply and Sanitation Technical Division (Western Cape) of WISA.



At the 4th meeting and workshop of the Landfill Specialist Interest Group of the Institute of Waste Management held in Constantia, Cape Town, were (from left) Professor Kobus Vorster (Pretoria Technicon), Mr Roger Parsons (Parsons and Associates) and Mr Peter Novella (Chairman: LSIG).



The Western Cape Branch of WISA sponsored a school visit to the Mitchells Plain waste-water treatment plant during Water Week.



The quarterly meeting of the WISA Water Care Technical Division (Western Cape) was held at the Kloofnek water filtration plant.

## UP Kortkursus flink bygewoon



Die Afdeling Waterbenutting, Universiteit van Pretoria, het onlangs 'n weeklange kortkursus oor die bedryf van geaktiveerde slykaanlegte aangebied. Die kursus is deur 22 persone vanaf plaaslike owerhede, verskaffers en raadgewende ingenieurs bygewoon. Op die foto is die kursusgangers tesame met die aanbieders, prof Frik Schutte (heel links) en prof At Pretorius (heel regs).

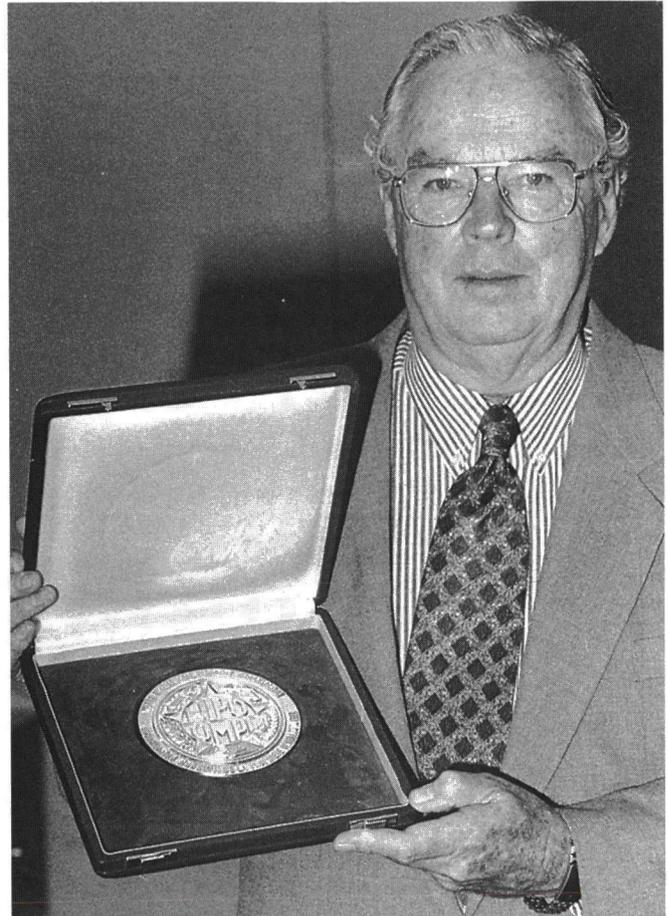
# SA design receives gold medal

The Enviro Loo, designed by Dr Brian La Trobe, has recently been awarded the 1997 Organisation for African Unity gold medal for the Best African Innovation of the year. The medal was presented to Dr La Trobe by the OAU chairman, President Robert Mugabe, during the recent OAU summit meeting in Harare.

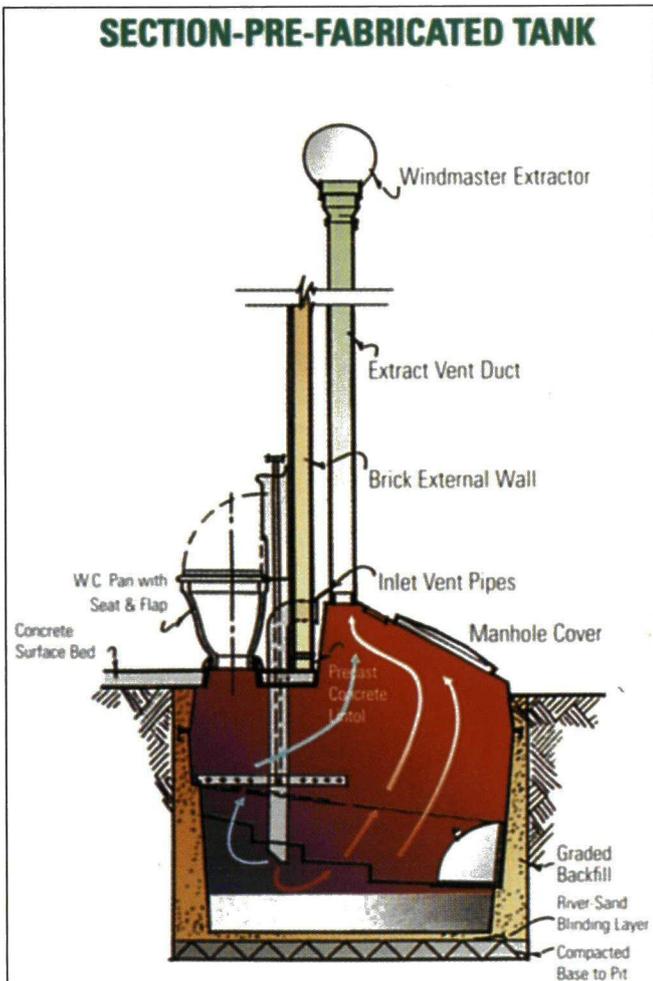
The Enviro Loo is a dry composting toilet which has been designed to be both user- and environment-friendly, as it does not use water, chemicals or electricity. "It is an effective sanitation solution for arid areas where a waterborne sewerage system would be out of the question", says Dr La Trobe. Most importantly, the Enviro Loo design prevents the seepage of sewerage into the surrounding environment or groundwater, and is therefore an excellent sanitation solution in high water table areas. As it does not require water it is ideal for longterm low cost sanitation.

The Enviro Loo looks like a water-flushing toilet and can be incorporated in a simple house design.

The toilet is a sealed plastic unit and costs less than R2000 to



*Dr Brian La Trobe holding the magnificent gold medal he received for his Enviro Loo design as the Best African Innovation of the Year.*



*The Enviro Loo design*

install. It works by separating the solid and liquid waste inside the plastic container. The liquid drains to a water trap at the bottom of the unit and the solid waste is retained on a series of drying grids and plates. The solid waste decomposes and dries to 10 per cent of its original mass.

The compost-like dried waste is not obnoxious, and does not present a health hazard. "Just like Nature recycles garden refuse into compost, the Enviro Loo creates the right environment allowing human waste, toilet paper and organic material to break down through the natural composting process into an inoffensive compost-like material," says Dr La Trobe. Oxygen, moisture, heat and organic material are required for aerobic bacteria and microbes to recycle human waste into a good fertilising material. The Enviro Loo design provides for radiant heat absorption and adequate oxygen for the aerobic decomposition and deodorising process.

For further information and brochures please contact: Enviro Options at Tel.(011) 708-2245, Fax (011) 708-2180. E-mail: 101754,757compuserve.com

# New Research Managers appointed a WRC

Jay Bhagwan and Greg Steenveld have been appointed as research managers at the Water Research Commission.

## Jay Bhagwan

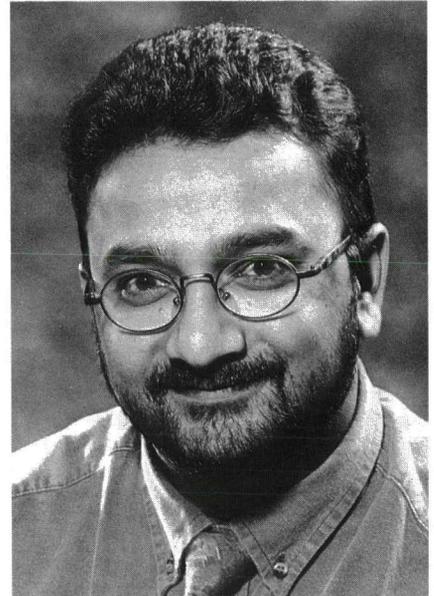
Jayant Bhagwan, a qualified environmental health engineer, has been appointed research manager in the field of water supply and sanitation.

Jay was born and raised in Durban where he completed his schooling and started university studies. He completed his undergraduate studies (1989) in civil engineering at the University of Nagpur, India. Thereafter he did a Graduate Diploma in Engineering at the University of the Witwatersrand. He worked as a project engineer for the Rural Advice Centre, an organisation that assists rural communities with advice to establish, manage and maintain their own water supply and sanitation projects.

In joining the CSIR he became involved in research, particularly the technology as well as health aspects and community management of water supply and sanitation. During this period he obtained an MSc in Tropical Public Health Engineering from the University of Leeds, UK.

Jay reckons that water supply and sanitation research should encompass more than mere technology as "the best technology in the world will not be effective if the community does not accept, manage and maintain it".

Jay is the proud father of a baby boy and an ardent football and cricket fan.



*Jay Bhagwan*



*Greg Steenveld*

## Greg Steenveld

Greg Steenveld's field of expertise is design and management of water and effluent treatment systems. He has been appointed research manager for industrial water and wastewater management.

He was born and schooled in Cape Town. He graduated from the University of Cape Town with a BSc (Chem Eng) in 1986. He continued with graduate studies in sanitary engineering and subsequently completed an MSc in chemical engineering.

His first job was with Ninham Shand, investigating pollution loads from indus-

tries in Wellington (RSA). He did graduate studies in Public Health Engineering at Newcastle (UK) in 1977 and gained ten years' experience in process engineering and project management working for international companies in Britain.

Since returning to South Africa in 1987 he has been involved in design and project management of effluent treatment, water re-use and by-products recovery systems for a wide range of industries.

Greg's other interests are guitar and folk music as well as films and TV sport.

# Artificial stream system helps develop water quality guidelines for the environment

Researchers at Rhodes University developed a recirculating artificial stream system to investigate the use of macro-invertebrates as water quality indicators.

The researchers, CG Palmer, PA Goetsch and JH O'Keeffe, from the Institute for Water Research at the university say in a report to the Water Research Commission, who funded the project, that the aim of this research is to contribute information which will assist in water quality management in South Africa.

South Africa faces two major water management issues: water quantity and water quality. Recently, water quality management changed from the uniform effluent standard approach to the Receiving Water Quality Objectives (RWQO) approach, which aims to manage water bodies in a state "fit for use", as defined by five recognised water users, namely, industry, agriculture, domestic supply, recreation and the natural environment. This was followed by the publication of water quality guidelines for all these users except the natural environment.

In terms of water quantity it was envisaged that the five users would compete for scarce water resources and each user would have to motivate for its share.

The researchers say there is, however, a fundamental problem with the concept of the natural environment as a competing user, as it is the resource, and requires assured maintenance before other users can apply for allocations.

"What is needed is a management approach which formally recognises the aquatic ecosystem as the resource, so both research and management can focus on the maintenance of aquatic systems in a functional state."

According to the report research on water quantity for environmental flow requirements for rivers is well advanced. The need for experimental research on the water quality requirements of riverine fauna was highlighted in 1989 at a Kruger National Park Rivers Research Programme (KNPRRP) workshop which was held to attempt to establish environmental water quality guidelines for the KNP rivers. It became apparent that no data existed on the water quality requirements or tolerances of any indigenous riverine organisms.

There are a variety of data sources for the development of environmental water quality guidelines: using the historical water quality record to calculate, for example, the 90th percentile of naturally occurring concentrations, using the con-

centrations in water bodies where populations and communities thrive naturally, existing international guidelines, and experimentally determined tolerance values.

The artificial stream project aims to use the experimental method of ecotoxicology to contribute to water quality management, including providing data for the development and refinement of environmental water quality guidelines.

The report says in South Africa, riverine macro-invertebrates have most frequently been collected from riffle habitats, which are also the main habitat sampled in bioassessment studies. In order to relate experimental data to field distributions and bioassessment data, the artificial stream system was designed for the use of riffle organisms as test animals. Since these current-dwelling organisms have specific hydraulic habitat requirements, the major specification for an experimental system was for a flowing water system where the range of hydraulic conditions could be accurately described.

## AIMS

Some of the immediate aims of this research project were to:

- Synthesise information on the design, construction, operation and research planning of experimental stream systems worldwide.
- Several designs and uses were seen in England, Australia, Canada and the USA. Literature was reviewed and is summarised in the report.
- Design, plan and build a recirculating artificial stream at Rhodes University together with smaller scale, portable, mesocosm laboratory systems.
- The artificial stream laboratory, with large and small-scale models, is fully equipped and functional. The design and potential use are presented in the report.
- Establish procedures for the selection and maintenance of stream macroinvertebrates and to design appropriate experimental procedures.
- Calibrate the experimental system by monitoring physico-chemical changes in channels containing only water, and water with substrate.
- Hydraulic, temperature and water quality calibrations are

complete, and behavioural calibration has been initiated.

- Conduct experiments on the tolerances of selected species to salinity, initially in the smaller laboratory recirculating systems and then in the experimental stream.

Tolerance experiments have been conducted in the small-scale raceways and are presented in the report. Tolerance testing in the large systems will commence as soon as behavioural calibration is satisfactory.

The researchers say: "In the immediate future the most useful application of this research is in the development and refining of environmental water quality guidelines. It is important to recognise that there was previously no knowledge whatsoever

of the tolerances of indigenous riverine fauna to any water quality variables, and that without such information we are limited in our ability to set realistic environmental guidelines. We are therefore at a stage in the development of environmental guidelines in which any results represent an advance in our knowledge, and it is in this respect that this project has been most successful."

Copies of the report entitled **Development of a recirculating artificial stream system to investigate the use of macro-invertebrates as water quality indicators** (WRC Report 475/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. Fax: (012) 331-2565. E-mail: Tineke@wrc.ccwr.ac.za. (Overseas price, including surface mail costs: US\$ 25.)

The design and construction of the artificial stream laboratory at Rhodes University were contributed by the Department of Water Affairs and Forestry. The laboratory provides a controlled environment, with a defined and replicated range of hydraulic conditions, so that experimental research can be conducted using rheophilous organisms.

Research has focused on the response of riverine macroinvertebrates to changes in water quality. The system is also ideal for the investigation of hydraulic requirements of riverine taxa. In Chapter 2 of the report the researchers briefly review artificial stream designs and provide design details of the artificial stream system which has been built.

One of the most obvious features of natural ecosystems is the complexity of interactive effects between abiotic and biotic variables. In an experimental approach, the general aim is to maintain certain variables constant while investigating the effects of others by altering them within controlled limits. Artificial stream research is based on the further premise that the provision of a flowing water environment is fundamental to any experimental research on riverine organisms.

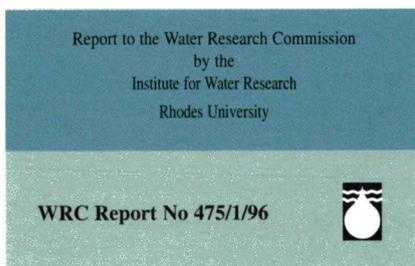
Stream design involved choices between alternatives, or selection over several gradients: 1) "naturalness" to complete operational control (indoors vs outdoors); 2) large to small; 3) recirculating or through-flow. Each choice has advantages and disadvantages, and decisions depend on the research question. Other considerations are the three major criticisms that have been

levelled at artificial stream research: 1) the limited degree to which results are applicable to the natural environment; 2) the physical scale of many artificial streams is too small for natural processes to occur; and 3) they are usually inadequately replicated, so it becomes impossible to assess within-system variability, and to evaluate between-treatment experimental results in comparison.



**Development of a Recirculating  
Artificial Stream System to  
Investigate the Use of Macro-  
Invertebrates as Water Quality  
Indicators**

CG Palmer • PA Goetsch • JH O'Keeffe



The artificial stream laboratory was designed with these options and criticisms in mind. The researchers say they accept that no indoor system can mimic the natural world, but argue that the operational control gained allows valuable opportunities for consideration of both single variables, and complex effluent effects. The system comprises models at two scales. There are three large systems, each with three chan-

nels (Figure A), and 15 small-scale models constructed on a raceway design (Figure B). The large 3-channel units are accommodated lengthwise in the laboratory, and three raceways are associated with each unit. This allows each experiment to run at two scales. Single variables can be selected and maintained at different experimental levels at both scales; and portable raceways can subsequently be taken into the field, and the experiment repeated under river-side conditions using river water and freshly collected animals. In this way the small-scale raceways are used for "field verification" of the large-scale channel systems, with laboratory raceways providing a comparison of scale effects.

The hydraulic and structural design of each unit proceeded from the specification of the required flow regime in the channels. In order to work with the whole range of rheophilous organisms, flows from low velocities (0.3 m/sec) to flows in excess of 1 m/sec were required: for example the pest species of blackfly *Simulium chutteri* is only found in velocities greater than 1 m/sec. From these flow rate requirements, appropriate pipe sizes, tank dimensions and the overall dimensions of the unit were progressively calculated. The large units recirculate 2 000 litres of water, and the raceways 25 litres.

In addition to the hydraulic control offered within each unit, other factors such as temperature, daylength and light can also be controlled in the laboratory.

In experiments where water quality variables are altered, the starting water quality must be specified. There is a range of alternatives. The laboratory is

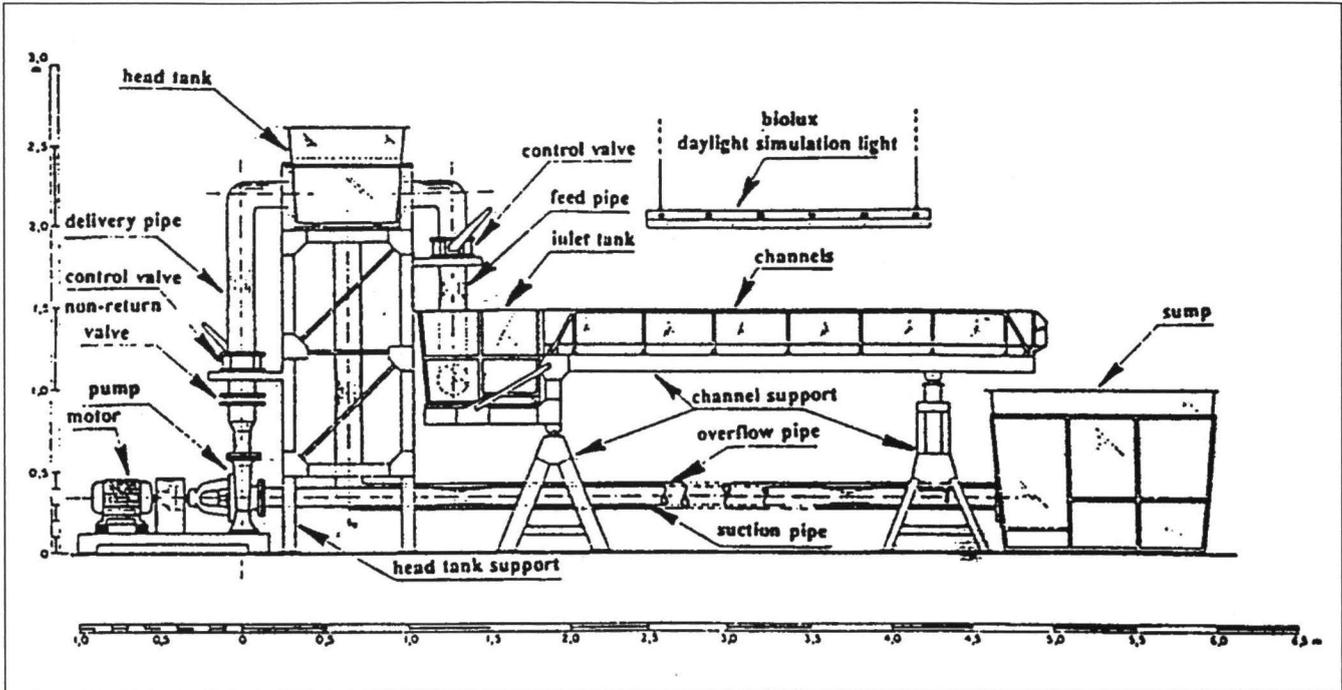


Figure A: An elevation of one of three 3-channel artificial stream units.

supplied with municipal tap water. There is a 10 000 litre rain tank outside, and local river water can be brought in by water tanker.

**CALIBRATION**

The term calibration is used in the report to describe the process of defining experimental conditions in the artificial stream laboratory. The objective of calibrating the streams was to establish the physical and chemical conditions in the streams before organisms were introduced; then to monitor the behaviour of organisms in the streams before water quality conditions were altered. Chapter 3 deals with hydraulic, temperature, water quality and behavioural calibration.

**□ Hydraulic calibration**

The first step was hydraulic calibration. This involved confirming that hydraulic conditions in each of the channels, and in the three systems, were the same for any given discharge and slope setting. Hydraulic conditions were measured for a range of slope, discharge and substrate settings so that experimental conditions could be selected and accurately described.

Each of the three 3-channel stream units is designed so that the flow delivered to the feed tank is distributed equally among the three channels; that

is to say for any combination of discharge and channel gradient, the average velocity and depth of flow at any

point in one channel should be the same at the equivalent points in the other two channels. Furthermore, the

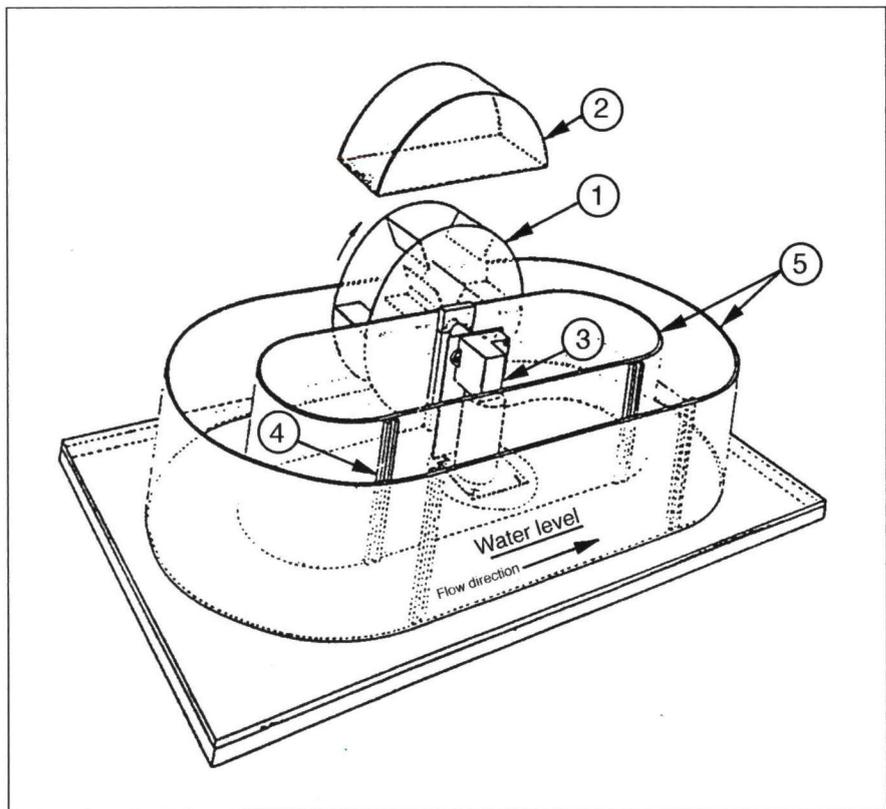


Figure B: Small-scale Raceway. One of the 15 perspex portable raceways used both in the artificial stream laboratory and in the field. 1: paddle wheel, 2: splash hood, 3: windscreen-wiper (DC or AC) motor, 4: slots for nets to contain test animals in the parallel part of the channel, 5: perspex walls.

design of each of the three stream units is identical, so that the same discharge/gradient combination in all three units should produce the same hydraulic conditions in all nine channels.

However, fabrication and constructional tolerances, together with slight differences in pump, motor and valve characteristics among units, combine to make this ideal intra and inter-unit similarity of hydraulic conditions unlikely to be achieved in practice. One objective of the hydraulic calibration was therefore to assess, against accurately metered flow rates, the accuracy of the three-way distribution of flow among the three channels of a stream unit. The suitability of the stream units for the purposes of the research project was based to a large extent on the ability of the channels to produce a specified range of velocity/depth conditions in the channels, as predicted by a 1-dimensional analysis of the channel hydraulics. A second objective was therefore to compare the hydraulic conditions obtaining in the units with those calculated, and to assess the success of the predictions. Since budget limitations precluded the incorporation of formal flow measuring devices into the stream units, the third objective was to establish control valve settings in each of the three units installed in the Grahamstown laboratory, so that the flow rate delivered to the channels was known as accurately as possible, and so that hydraulic conditions in each of the three streams could be set as nearly as possible the same.

#### □ Temperature calibration

The system has a combination of temperature control options. The laboratory is air conditioned, and each set of channels has a water chiller. The air conditioners were capable of maintaining the laboratory temperature between 16 and 26°C, within 1°C. Water temperature in the channels, when the pumps were not running, was maintained at 1 - 2°C lower than the laboratory temperature over a period of 10 days. Running the pumps raised the water temperature by 2.8°C. The chillers reduced the water temperature by 2.8°C ± 2°C.

#### □ Water quality calibration

Since the artificial streams were designed to conduct invertebrate water quality tolerance experiments it was important to establish the range of

water quality variation in the systems when they were run over periods of time longer than the envisaged experimental times. Acute 96 hour (4 days) experiments were planned, and water quality calibration experiments were run over seven days. Systems were monitored with water, then with substrate added, and finally with substrate and organisms (to ascertain the effects of test populations on water quality). Water quality calibration proved to have additional significance in the context of the ultimate statistical analysis of experimental data.

Bearing in mind the lack of within system independence, the aim of the water quality calibration in the large systems was twofold: 1) to describe between system variation; and 2) to describe within system variation over 7 days. The raceways were independent, so they were monitored for between raceway variation, also for seven days.

Water quality calibration experiments were conducted in both the large stream systems and in the small-scale raceways. When streams were filled with municipal water they were run for 48 hours to remove chlorine, as they would be in a tolerance experiment. Day 1 commenced after this dechlorination period, but when rainwater was used monitoring commenced immediately. Temperature, pH, and conductivity, as well as nutrient concentrations (ammonium, nitrite, nitrate and phosphate), were measured three times per day for seven days. The raceways were filled with municipal water (dechlorinated using a carbon filter), or rainwater, and the same variables were measured once per day for seven days. The stream system and raceway runs were not conducted simultaneously, but were both conducted in the artificial stream laboratory.

#### □ Biological calibration

It was necessary to understand test organism responses to the experimental system before the water chemistry was changed, as these are the conditions that would be the controls during an experiment. The process of defining organism response was termed behavioural calibration. Since an exhaustive approach was not feasible, a small selection of slope, discharge and substrate conditions were selected, and organism responses observed. Behavioural calibration in the large

streams has been largely unsuccessful, and more research is required to optimize these systems.

One of the requirements for ecotoxicity testing is a maximum of 10 per cent mortality in the control population. So far this has been impossible to achieve at either scale using wild populations of riverine macro-invertebrates.

## TOLERANCE TESTING

Chapter 4 describes the experimental determination of salinity tolerances of indigenous riverine macro-invertebrates. Salinisation has been widely described as posing a serious threat to South African freshwaters, and was therefore identified by the artificial stream project as the first variable to be investigated during this study.

One of the aims of this research was to establish a guideline value for salinity (measured as conductivity) for the protection of the aquatic community, and subsequently the natural environment. Two salts, sodium chloride and sodium sulphate, were selected for tolerance testing at a range of conductivities and concentrations. Experiments were carried out in the artificial stream laboratory in Grahamstown (Eastern Cape) using a baetid population from the nutrient-enriched Bloukrans River, and in the Kruger National Park (Mpumalanga) using the mayfly *Tricorythus* sp. from the unpolluted Sabie River. Salinity tolerances of the Bloukrans River limpet *Burnupia stenochorias*, and the Sabie River caddisfly *Chimarra* sp., were briefly investigated in range-finding experiments. A 96 hour experiment was also carried out to investigate the tolerance of Sabie River *Tricorythus* sp. to water of the polluted Selati River. Water chemistry and mortalities were monitored throughout the experiments.

Despite the difficulties encountered during this method development phase, it presents a unique opportunity to experimentally observe and monitor the behaviour of riverine organisms under conditions of salinity stress. Toxicity testing using riffle-dwelling macro-invertebrates in recirculating raceways appears to present a useful contribution to the science of ecotoxicity testing, and to the development of water quality guidelines for the protection of the natural aquatic environment.

# Researchers look at human viruses in water environments

There is hardly any meaningful, confirmed epidemiologically evidence on waterborne diseases in South Africa according to researchers from the Institute of medical virology at the University of Pretoria.

In a report to the Water Research Commission on viruses in water environments, the researchers, WOK Grabow, MB Taylor and M Wolfaardt, say that viruses may account for up to 75 per cent of infections associated with polluted water.

"Assessment of the virological safety of water is, therefore, of fundamental importance. Unfortunately, viruses are not detectable by simple and inexpensive methods, while commonly used indicators of faecal pollution such as coliform bacteria, have shortcomings for indicating the presence of viruses, or the efficiency of water treatment procedures with regard to viruses."

The researchers say the development of practical technology and expertise for assessment of the virological quality of water, and the removal of viruses in treatment and disinfection processes is, therefore, of major importance to the water industry.

A fundamental approach to the control of waterborne disease is to limit the pollution of water sources. This is particularly

Since infection may be caused by a single viable viral particle, both quality monitoring of water supplies and research on waterborne viruses require sensitive and practical techniques for detection of the smallest possible number of viruses in water. Ongoing research in many laboratories worldwide is focused on this challenge. Efforts and progress accomplished as part of this project may be summarised as follows:

A practical and economic technique for the in-line and on-site recovery of viruses from water adsorbed onto glass wool adsorption-elution filters has been developed and evaluated. The efficiency of recovery for a variety of human viruses compares favourably with that of procedures commonly used for this purpose. The inexpensive filters are convenient to use and can readily be forwarded to a laboratory for the recovery and detection of viruses. The pro-

cedure has been introduced for the routine monitoring of the virological quality of raw and treated water supplies of Rand Water.

An affinity chromatography (AC) procedure for the selective recovery of specific viruses from water has been developed and evaluated. The technique is based on filter columns containing agar beads to which antibodies directed against the virus of choice have been attached. When water is passed through these columns, the antibodies trap the viruses concerned while other viruses and impurities pass through. The viruses can afterwards be released from the antibodies in concentrated and purified form detection. This method has valuable features for application in, for instance, studies on the role of water in specific disease outbreaks.

Technology for the isolation of viruses by propagation in cell cultures has been

important with regard to viruses, because they may remain viable for weeks or months in water environments, and they are exceptionally resistant to water treatment processes. Also, the minimal infectious dose of viruses may be as low as a single viable particle. Information on sources of pollution is essential for the protection of water sources. There is, however, no information on the contribution of various waste water discharges to the contamination of water sources specifically with regard to viruses.

Against this background the Water Research Commission (WRC) funded a project at the UP Institute of Medical Virology to:

- Develop technology and expertise for research on human viruses in water, as well as the epidemiology of waterborne viral diseases; and
- Evaluate the contribution of waste water from informal settlements to the virological pollution of water sources.

A report summarising the final results is available free of charge from the WRC offices in Pretoria. It is titled **Research on human viruses in diffuse effluents and related water environments** (WRC Report 496/1/96). (Overseas price, inclusive of a surface mail charge, is US\$ 20.)

improved. In a detailed comparison of 8 cell culture systems, evidence has been presented that the most sensitive practical procedure requires the simultaneous inoculation of the following cell cultures: Primary vervet kidney cells, the BGM Green Monkey kidney cell line, and the PLC/PRF/5 human liver cell line. The susceptibility of each of these cell cultures for various viruses differs, but in combination at least any one of them supports the replication of a wide variety of viruses. "This combination of cell cultures is now routinely being used in our laboratory for the virological analysis of water. We are not aware of a more sensitive cell culture system being used for the detection of viruses anywhere in the world," says Prof Grabow. Evidence has also been presented that meaningful detection of viruses in water environments requires at least three passages, even in this sensitive combination of cell cultures. This is because many viruses are still infectious, but

have been injured by prolonged exposure to unfavourable conditions in the water environment to the extent that they fail to replicate immediately in cell cultures and require some time for recovery.

In order to increase the sensitivity of cell cultures for the detection of viruses in water, efforts have been made to modify the susceptibility of cell cultures. Selected cell cultures were treated with certain chemicals known to affect viral infection under certain laboratory conditions.

Treatment of cell cultures with 5-iodo-2'-deoxyuridine (IDU) increased the sensitivity to laboratory strains of poliovirus by up to 100-fold. In addition, the cytopathogenic effect caused by the virus in the cell culture was much clearer and detectable 2-4 days sooner than in untreated cell cultures. Treatment of cell cultures with various other chemicals, such as polyethylene-imine (PEI) also increased the sensitivity of some cell cultures to laboratory strains of viruses, although in most cases only by a factor which ranged from 2 to 10-fold. Initial findings indicate that the sensitivity of cell cultures to naturally occurring viruses is similarly increased, and both most probable number (MPN) assays and direct plaque assays on numbers of cytopathogenic enteric viruses in water environments yielded higher counts using treated cells. In addition, treatment of cells with IDU considerably facilitated the detection of cytopathogenic effects and reduced the time required for the detection of viral infection which has meaningful benefits.

Unfortunately many waterborne viruses are not detectable by conventional cell culture procedures as described above. This is because although viable they fail to produce a visible cytopathogenic effect, at least in cell cultures presently available and under laboratory conditions presently applied. These viruses are referred to as non-cytopathogenic. The detection of these viruses requires alternative methods. Overseas human volunteers have often been used in research on these viruses. Progress in work on the detection of non-cytopathogenic viruses carried out in this project may be summarised as follows:

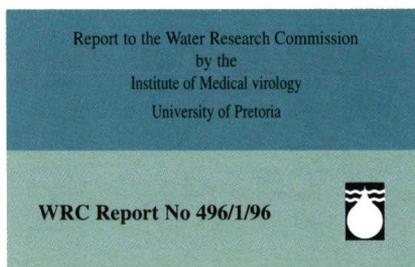
Some non-cytopathogenic viruses infect cell cultures and get so far as to replicate their nucleic acid and some

capsid proteins, but fail to produce complete viral particles or a visible cytopathogenic effect. Techniques have been established for detecting the nucleic acids and capsid proteins in cell cultures of viruses which display this phenomenon. These viruses include astro, hepatitis A and rota. The advantage of this procedure compared to methods based on the detection of non-cytopathogenic viruses by direct detection of their nucleic acids or capsid proteins, is that it confirms the viability of viruses, and increases sensitivity because the quantity of nucleic acid and capsid protein is replicated, ie amplified, by the cell cultures.



**Research on Human Viruses in  
Diffuse Effluents and Related  
Water Environments**

WOK Grabow • MB Taylor • M Wolfaardt



Non-cytopathogenic viruses may be detected by electron microscopy (EM). Unfortunately this method, requiring sophisticated facilities and expertise, cannot distinguish between viable and non-viable viruses, and conventional procedures cannot detect less than about 1 000 000 particles per ml. In addition, conventional electron microscopy cannot distinguish between many morphologically similar viruses, such as coxsackie, polio, echo and hepatitis A viruses. In this project modifications have been established in which specific antibodies are used to clump viruses for increased detection sensitivity (a procedure known as immune electron microscopy), and to facilitate distinction between morphologically similar viruses. This procedure is now routinely being used in the typing of viruses isolated from water. It has also been used for the first time in

South Africa to study the role of potentially waterborne calici- and astroviruses in cases and outbreaks of gastroenteritis.

Non-cytopathogenic viruses may be detected by procedures in which antibodies specific for capsid proteins (antigens) are used. Attachment of the antibodies to the viruses is detected by labelling the antibodies with enzymes which catalyse a colour reaction (enzyme-linked immunosorbent assays, ELISA) or other markers such as radioisotopes (radio-immuno assays, RIA). The level of sensitivity of these immunoassays is about the same as that of EM, and like EM they cannot distinguish between viable and non-viable viruses. Although not sensitive enough for meaningful monitoring of water quality or assessment of the efficiency of treatment processes, these methods are ideally suited for the detection of non-cytopathogenic viruses in the stool of infected individuals. In this project immuno-assays for various viruses have been established and used in research on infections in individuals exposed to polluted water. These techniques were, for instance, used in the first research in South Africa on infections by gastroenteritis viruses such as the Norwalk virus, other calciviruses and astroviruses in canoeists exposed to sewage polluted river water, and in consumers of sewage-polluted drinking water.

The above immuno-assays can be carried out in reverse, ie, using viral antigens to detect the presence of antibodies directed against certain viruses in the blood (serum) of people. Specific antibodies are produced in response to viral infections. This implies that the presence of antibodies directed against a certain virus implies that the person has been infected by that virus. The detection of specific antibodies is routinely used for the laboratory diagnosis of viral infections. The method is particularly valuable in the diagnosis of infection by non-cytopathogenic viruses. This implies that infections can be confirmed without ever detecting the causative virus itself. This has the further implication that the presence of antibodies in people offers fail-safe evidence of the presence of the virus. In this project assays for a number of potentially important waterborne viruses have been established and optimised. These methods have, for instance,

been used to submit the first evidence that the hepatitis E virus (HEV) occurs in South Africa. The HEV is notorious for waterborne outbreaks in some parts of the world. For instance, in 1991 a sewage polluted drinking water supply caused an outbreak of hepatitis E with some 79 000 cases in Kanpur, India. Hepatitis E is clinically similar to the well-known hepatitis A, and both are typically waterborne, but the viruses which cause these diseases are clearly distinguishable and belong to different families of viruses. In this project surveys for antibodies (seroprevalence studies) have also been used to monitor infections by other non-cytopathogenic viruses such as calici and astro gastroenteritis viruses in canoeists exposed to polluted river water, people who consumed sewage polluted drinking water, and individuals involved in outbreaks of gastroenteritis caused by potentially waterborne viruses.

The above methods have also been incorporated in a refined protocol for the routine typing of viruses isolated from water environments. This protocol includes cytopathogenic effects in cell cultures, the inoculation of newborn mice, cell culture neutralisation assays, investigation of inclusion bodies in stained cells, electron microscopy, and immunological tests.

The approach to the detection of non-cytopathogenic viruses which is worldwide rapidly gaining ground is based on the detection of the nucleic acid of viruses by means of molecular techniques such as the polymerase chain reaction (PCR). These detection techniques are extremely specific, the sensitivity may be superior even to that of cell culture propagation, and results are usually available considerably sooner than those of cell culture propagation. Disadvantages are that at this stage these methods are generally speaking still in a development stage and require sophisticated facilities and expertise. However, rapid progress is being made in the simplification of the procedures and commercial test kits are already available for some viruses such as the AIDS-virus. An important disadvantage of these techniques is that they cannot distinguish between viable and non-viable viruses. However, they still have major benefits for water quality assessment. For instance, the absence of viruses from water, "dead or alive" implies that the water is safe. Positive

results would imply a potential risk because some of the viruses may be viable, and the presence of these viruses also indicates the potential presence of other viable viruses. The extreme specificity of these methods is also used to type viruses. In this project PCR procedures have been established for the detection of a number of non-cytopathogenic viruses, including calici, astro, hepatitis A and E, enteric adeno, and rota. Results of the first comparative assays also indicate that our PCR procedures for cytopathogenic viruses are more sensitive and faster than cell culture propagation, and the experimental application of PCR procedures for the routine monitoring of enteroviruses in water supplies is in progress.

## EPIDEMIOLOGICAL STUDIES

According to the report two outbreaks of gastroenteritis have been studied. The causative agents have been identified as certain types of caliciviruses. These were the first recordings of involvement of the viruses concerned in outbreaks of gastroenteritis in South Africa. The same or closely related viruses are known as common causes of gastroenteritis in at least some parts of the world, and their transmission is typically associated with water and food. Although contaminated food was eventually identified as the most likely source of infection in both outbreaks studied as part of this project, the investigations offered a valuable opportunity to evaluate expertise for research on disease outbreaks associated with contaminated water, and to identify the aetiological agent.

### □ Dusi

Epidemiological studies were carried out on participants in the Dusi Canoe Marathon which is each year in January contested down the Umsindusi and Umgeni Rivers from Pietermaritzburg to Durban. The water in these rivers is exposed to sewage pollution, and at least at times counts of faecal coliform bacteria and coliphages exceeded levels generally accepted as safe for water intended for direct contact recreation. Analysis of data obtained by questionnaires indicated a significantly higher incidence of clinical complaints potentially related to infections by waterborne viruses among participants with extensive exposure to the river water than among accompanying persons with limited or no exposure to the water.

### □ Knysna

In August 1994 data were gathered on a typical waterborne outbreak of gastroenteritis in a suburb of Knysna. Gastroenteritis viruses were detected in stool specimens of clinically ill patients. Enteric viruses were isolated from the drinking water supply. The water also contained levels of faecal coliforms, enterococci, and somatic and male-specific coliphages in excess of limits recommended for drinking water. Faecal pollution was ascribed to an error in the drinking water supply system.

### □ Astroviruses

Astroviruses were detected in about three per cent of more than 1 000 stool specimens from gastroenteritis patients, predominantly children. This indicates that the incidence of these viruses typically associated with waterborne transmission is similar to that in many other parts of the world, which implies that the risk of waterborne transmission may be similar to that in countries where waterborne transmission is on record.

### □ Caliciviruses

In another study analysis of more than 1 000 stool specimens from gastroenteritis patients, including hospitalised children and adults, some of which cases from two outbreaks, indicated that the incidence in South Africa of caliciviruses such as Norwalk virus, was similar to that in other parts of the world where these viruses are typically associated with waterborne transmission.

### □ Hepatitis E

A seroprevalence study on 555 Dusi canoeists exposed to polluted river water and 227 Pretoria students with no meaningful exposure to sewage polluted water, revealed an overall 2,05 per cent incidence of antibodies to the hepatitis E virus. This was the first meaningful evidence of the presence of the hepatitis E virus in South Africa. These findings have since been confirmed by others who reported the presence of hepatitis E antibodies in up to 14 per cent of individuals in certain high risk communities. Apart from one retrospective study in which serum analyses indicated that clinical hepatitis in certain patients was probably caused by the hepatitis E virus, there is no record of clinical cases of infection contracted in the country. The absence or rare incidence of clinical cases of hepatitis E remains to be explained. Important, however, is that there is sound evidence

of the virus being present in the country, which implies that the possibility of waterborne hepatitis E outbreaks similar to those in certain other parts of the world cannot be ignored.

#### □ Studies on diffuse effluents

Research on the quality of diffuse effluents from informal settlements with restricted sanitary services focused on two sites, namely Botshabelo near Bloemfontein, and Stanza Bopape Village in Mamelodi, Pretoria. At both sites representative samples of effluents and related water environments were collected over a period of one year in order to cover all seasons. Analysis of the samples, characterisation of faecal indicators, typing of viral isolates, and processing of results took much longer. Final results and conclusions are summarised in the report.

### TECHNOLOGY DEVELOPED

□ A user-friendly glass wool adsorption-elution procedure for the economic, simple, in-line and onsite recovery of viruses from water has been successfully developed for water quality monitoring. This system has considerably reduced the cost and convenience of routine virological water quality monitoring. The affinity chromatography procedure for the selective recovery of viruses of choice from water is ready for application in studies on for instance epidemiological investigation of waterborne outbreaks and research on specific viruses.

□ The establishment of a combination of cell cultures and protocol for the sensitive and reliable isolation of cytopathogenic viruses is an important contribution to technology and expertise for water quality monitoring and research on waterborne viruses.

□ In the past the cost of analysing a water sample for viruses using cell culture detection was about 10 to 100 times more than that of a test for faecal coliform bacteria. These virus tests can now be offered at about 5 to 10 times the cost of faecal coliform tests. Unfortunately the tests still require relatively sophisticated facilities and expertise.

□ Progress in the development of methods for viruses not detectable by cell cultures now offers opportunities to

address many viruses for the first time in research and water quality assessment in South Africa. These viruses include hepatitis A and E, calici, rota, astro and adeno, which are most commonly associated with waterborne transmission. This work facilitated the first inclusion of molecular techniques as an integral part in routine water quality monitoring in South Africa.

□ The molecular techniques presently available have potential for substantial further development and improvement with regard to sensitivity, reliability and the spectrum of viruses detectable. At this stage the techniques still require relatively advanced laboratory facilities and skills. However, there is reason to believe that these tests can eventually be simplified and that the cost can be reduced to levels within reach of many laboratories. PCR test are already available in the form of relatively simple and inexpensive commercial kits for detecting viruses such as the AIDS virus in patient serum.

□ Studies on outbreaks of diseases caused by enteric viruses offered an opportunity to optimise technology and expertise for research on waterborne diseases. The results yielded the first evidence of the presence in South Africa of viruses which are known to have caused waterborne disease outbreaks in other parts of the world. Of special interest in this regard is the first evidence that the hepatitis E virus (HEV) may be endemic in South Africa. This calls for further research because HEV frequently causes waterborne hepatitis outbreaks in certain parts of the world. It is not clear why such outbreaks apparently have not yet occurred in South Africa. There is no reason to believe that such outbreaks cannot occur in the country.

The outbreak of waterborne viral disease at Knysna is typical of outbreaks on record for many parts of the world. This incident illustrates the vulnerability of drinking water supply systems to contamination and underlines the importance of reliable water quality monitoring.

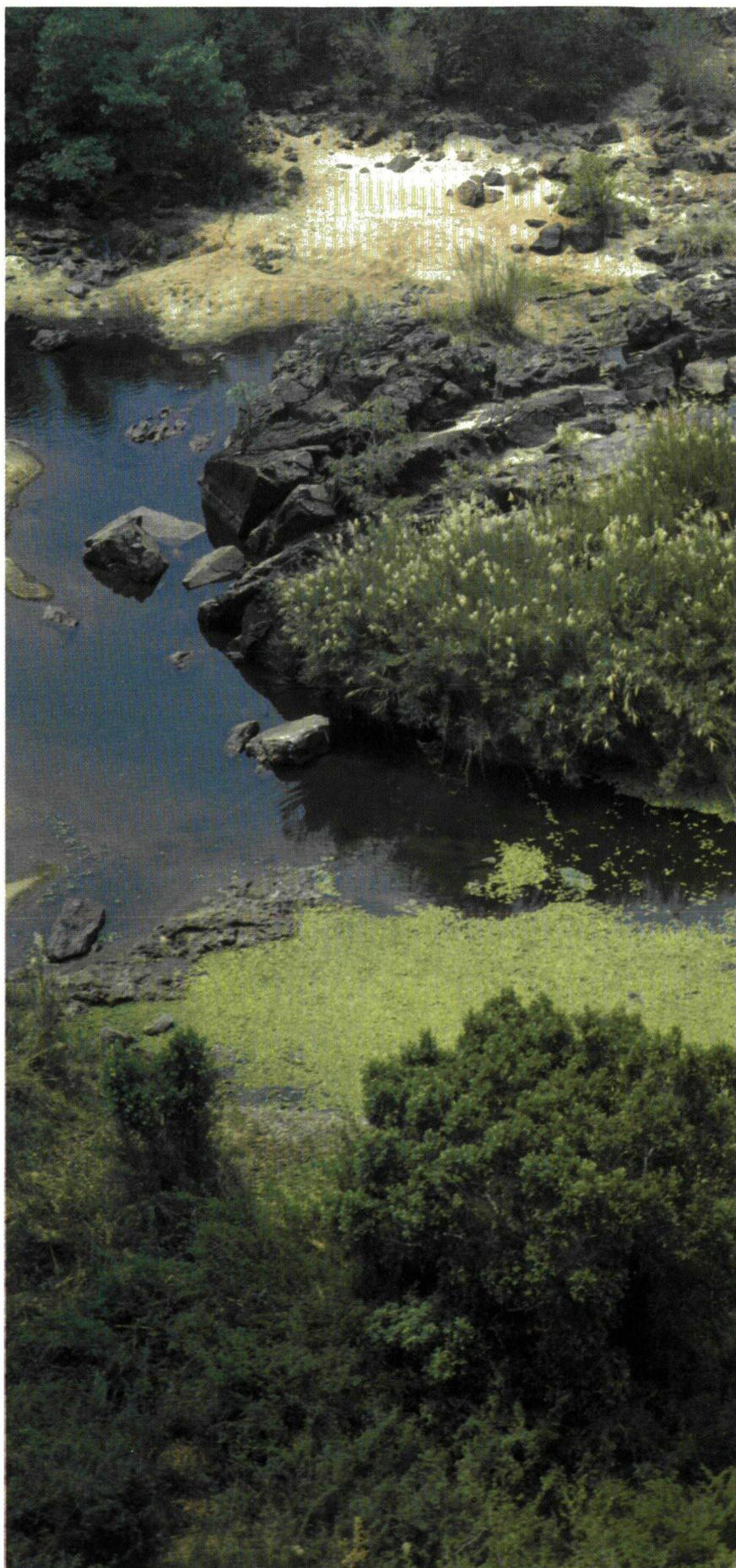
The two study areas selected for assessment of the impact of diffuse effluents from informal settlements on water sources were according to all indications typical examples of similar situations in many other parts of the

country. Effluents at both sites contained exceptionally high counts of faecal bacteria and phages, and these effluents substantially increased the levels of faecal pollution of receiving waters. Indirectly related information has also been obtained from the Dusi Canoe Marathon with recreational exposure to river water subject to faecal pollution from sources including diffuse effluents from informal settlements. The results of all these investigations show that diffuse effluents from informal settlements with restricted or no sanitation carry heavy loads of faecal organisms, and in at least some cases, also large numbers of viruses. Diffuse effluents from informal settlements may, therefore, constitute a major source of faecal pollution, including heavy loads of viruses, to water sources such as receiving streams, rivers and impoundments. These observations call for special attention to sanitation at informal settlements with due respect to the following considerations:

■ The pollution of receiving waters constitutes a health risk to people who directly use the water for recreation, washing, irrigation, and domestic purposes, as often happens in developing communities.

■ The public health implications of the risk of infection constituted by this pollution of water sources should not be underestimated. Many of the viruses and other pathogens concerned may have a low mortality rate and the consequences may largely be limited to socio-economic disease implications. However, this pollution of water sources also offers ideal opportunities for the rapid spread of more serious diseases such as typhoid fever, cholera, poliomyelitis and hepatitis E. Once a case of these diseases occurs in a community and the pathogens infiltrate water sources it becomes extremely difficult if not impossible to prevent outbreaks or epidemics with potentially disastrous consequences.

■ The data on viruses in this study are limited to cytopathogenic viruses detectable by cell culture. These viruses probably represent the tip of the iceberg of waterborne viruses, excluding virtually all gastroenteritis and hepatitis viruses, which are most commonly involved in waterborne disease, but not detectable by cell culture propagation.



# A River

## - drought effects

A comprehensive monitoring programme on the Sabie-Sand River throughout the drought period of 1991-92 offered an opportunity to address species and community responses to shrinking habitats and vastly fluctuating chemical environments, say researchers SR Pollard, DC Weeks and A Fourie in a report to the Water Research Commission. The report **A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga, with special reference to predicted impacts on the Kruger National Park** Volume Two: Effects of the 1992 drought on the fish and invertebrate fauna (WRC Report 294/2/96) documents the drought effects on the aquatic fauna, as well as the river habitat and water quality.

### **DROUGHT EFFECTS**

According to the report the main channel of the Sabie River was still flowing in September 1992 albeit at very low flows, however, the physical habitat changed as a result of progressively decreasing flows. The appearance of opportunistic invertebrate species in the riffle emphasised the drastic deterioration of habitat. The absence of suitable habitat seemed to be a more important factor than deteriorating chemical parameters.

The researchers found that in general the run and riffle areas maintained a constant species diversity of fish, although abundances declined. As the

# er runs low...

## s on Sabie River documented -

drought progressed, the dominance of cyprinid species such as *Barbus viviparus* was replaced by cichlids such as *Tilapia rendalli*.

The riffle areas was initially dominated by *Chiloglanis paratus* but the abundance of this flow-dependent species decreased notably with the progression of the drought, eventually *B. marequensis* became the most abundant species in the riffle.

In isolated pools a pronounced change in invertebrate community structure, accompanied by a loss of numbers of taxa and thus species diversity, was noted as the drought conditions intensified. A complete change from a lotic to a lentic community was obvious from the high numbers of Copepods and Cladocerans and the marked absence of the more flow-sensitive species.

**A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga with special reference to predicted impacts on the Kruger National Park**

Volume Two

Effects of the 1992 drought on the fish and invertebrate fauna

SR Pollard\* ● DC Weeks\* ● A Fourie\*

Report to the Water Research Commission  
by the

\*Freshwater Research Unit, University of Cape Town, and  
#Institute for Water Research, Rhodes University

WRC Report No 294/2/96



The substantial domination of Mozambique tilapia, *Oreochromis mossambicus* in almost all habitats during the drought is ascribed to the wide physiological tolerance and reproductive ability of this species, facilitating its survival in adverse conditions. However, although *O. mossambicus* dominated

overall catches, closer examination revealed that this species was rare in shaded pools.

The researchers noted that the distribution of certain species was positively correlated with off-stream cover (shaded pools).

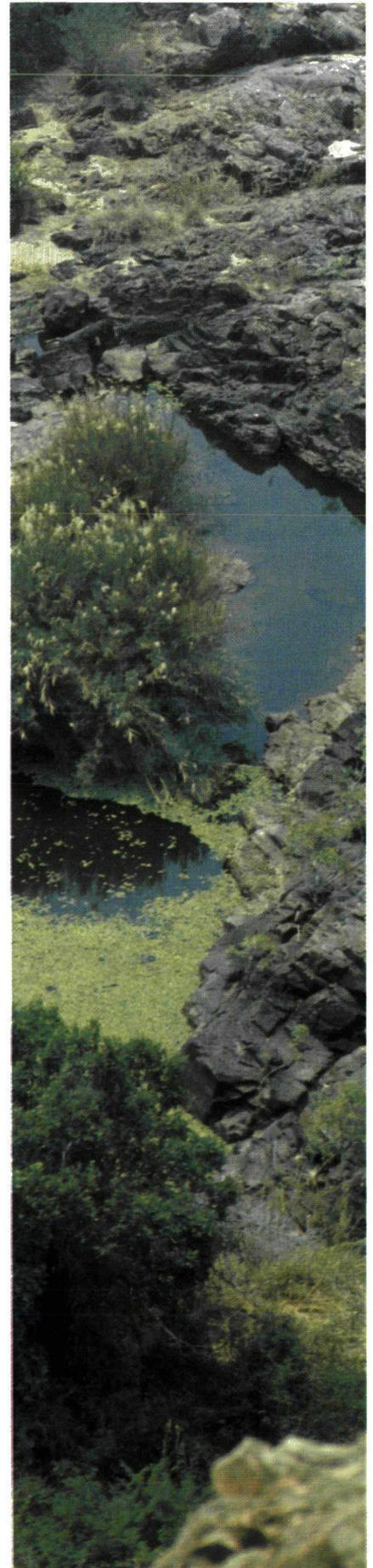
### **SURVIVAL**

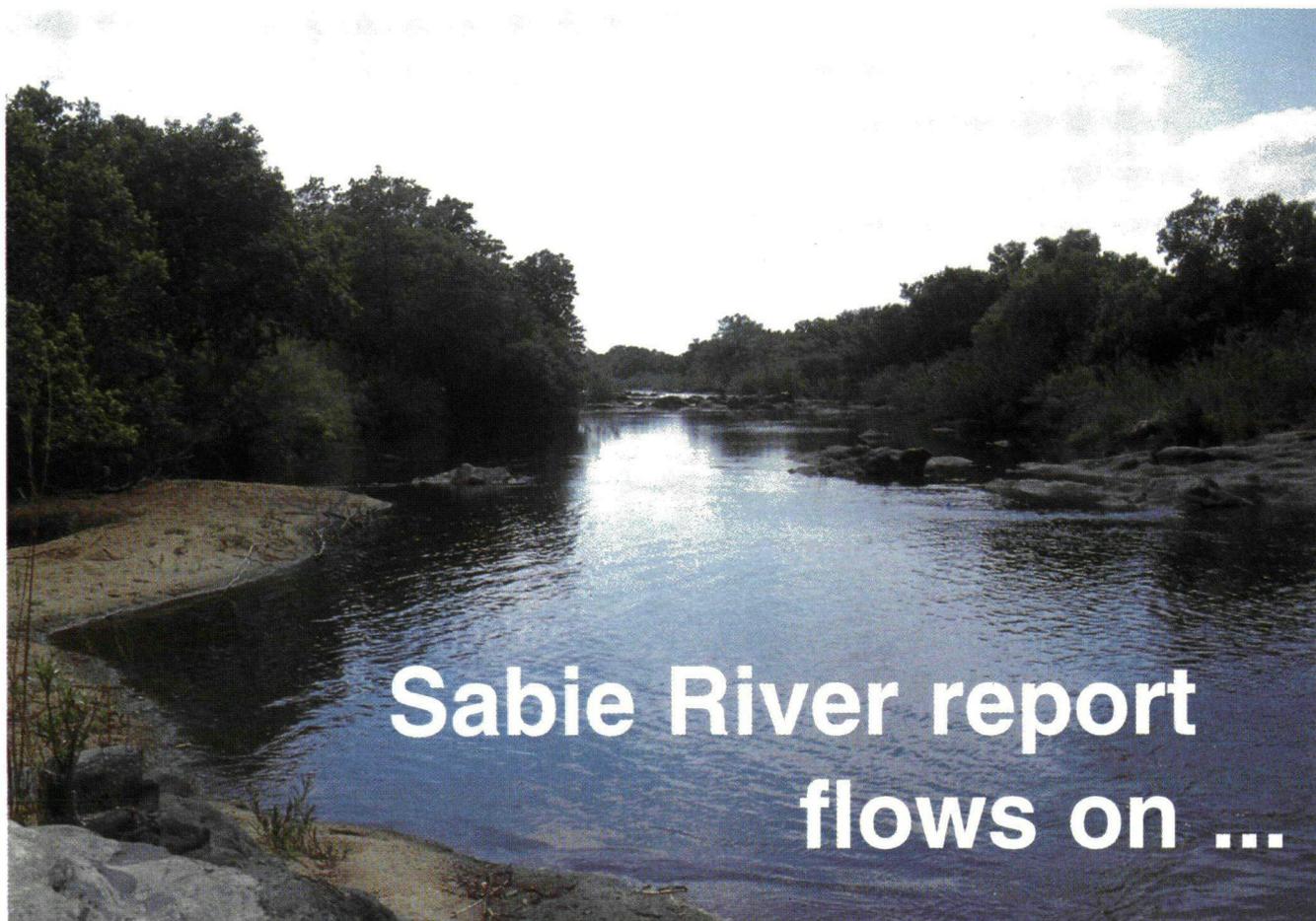
Some fish species were capable of surviving the extreme conditions of the drought either by behavioural or physiological adaptations, although abundances decreased in almost all species. However, a number of species that were numerous at the start of the dry season disappeared from the pools in the latter months. As pools became shallower certain species showed signs of stress manifesting in disease. A number of species appeared to be particularly susceptible to disease, and possible drought-related causes are mentioned in the report.

With respect to invertebrates, the disappearance of taxa such as Ephemeroptera and Trichoptera very early in the study period indicated a deterioration in conditions imperative for their survival.

The physical variables and pool habitat characteristics which determined the quality of the various refuge pools, as well as water quality parameters which also play an important role in determining the availability/suitability of habitat for aquatic fauna are comprehensively discussed in the report.

The report **A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga, with special reference to predicted impacts on the Kruger National Park** Volume Two: Effects of the 1992 drought on the fish and macro-invertebrate fauna (WRC Report 294/2/96) is available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. Foreign orders: US \$25 per copy of Volume II (via surface mail).





## Sabie River report flows on ...

"The overriding priority for the main Sabie River is to maintain a perennial flow to the Mozambique border. The maintenance of perennial flows in refuge areas, through out the Sabie-Sand River system, is crucial for the fauna to survive critical low-flow periods. Even in temporary tributaries it is necessary to ensure some base flow from time to time, to top up pools and improve water quality. Flow management policy should attempt to build in as much of the natural between and within seasonal variability", say research-

ers JH O'Keeffe, DC Weeks, A Fourie and BR Davies in a report to the Water Research Commission. The report entitled **A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga, with special reference to predicted impacts on the Kruger National Park** Volume Three: The effects of proposed impoundments and management recommendations, is the third of three volumes reporting on the Sabie-Sand River research project.

**V**olume III of the report is management orientated. The researchers assess the probable effects of proposed impoundments on the Sabie-Sand River, and, drawing on the information in volumes I and II, attempt to give future monitoring and management guidelines. Volume I\*\* reported the ecological status of the Sabie River, while Volume II comprehensively describes the effects of the recent drought period which gives an indication of the effects of permanent low flows.

The results of the three year survey of the Sabie-Sand River show that

- ❑ the water quality in the Sabie River is still excellent, and
- ❑ all species recorded in a 1978 survey are still present in the river, however, if low flow conditions become the norm, the communities in the Sabie will change considerably.

According to the report the middle reaches of the Sand River have been reduced to seasonal flow during most

years, with the result that the communities are significantly different from those of the perennial reaches. This makes the maintenance of the perennial upper warm tributaries of vital importance as refuges for recolonisation.

### SCENARIOS

The consequences of different flows on habitat availability, water quality and the instream fauna are addressed in tables in Volume III. The researchers say that

\*\* Volume I of the report of this research on the Sabie River has been announced and summarised in the article "Researchers determine ecological status of the Sabie River" in the previous issue of the SA Waterbulletin (Vol 23 no 2, March/April 1997).

the tables are designed to provide a structured summary of the effects of a series of flow scenarios of varying duration, during the wet and dry seasons. Predictions are given partly quantitative and partly qualitative.

## DAMS

Volume III deals with the effects of proposed dams on the river and river flows, also referring to the known effects of dams on the Buffalo River (eastern Cape) and the Palmiet River (western Cape). The effects of the seven existing impoundments and eight potential dam sites identified on the Sabie are discussed comprehensively in this volume.

The researchers say that most of the proposed dams are probably too small and too remote from the Kruger National Park to provide effective low flow augmentation. However, the proposed Madras Dam on the Sabie main-stream and very close to the Park, would have severe effects on the water quality, temperature and sediment transport within the Park, and is also large enough to intercept all except the largest floods. The Inyaka Dam on the Marite tributary would be the option of choice from an environmental point of view. This would have consequences for the Marite River, but is far enough from the Park for conditions downstream in the Sabie River to recover.

While existing and proposed impoundments on the Sand River are all remote from the Park and associated private reserves, they do affect the important perennial upper tributaries which act as refugia during droughts.

The effects of the construction and recent collapse of the Zoeknag dam in the Sabie-Sand River catchment are also discussed in this report.

## REDUCED FLOWS

The researchers give indications of the expected effects of reduced flows on:

### □ Fish communities

The effects of flow reductions on the fish communities of the Sabie-Sand have to be seen in the framework of the different zones of the rivers, and during the wet and dry seasons. In the Foothill Zone (FHZ), there are less seasonal effects, and the consequences of

reduced or no-flow would be the reduction or disappearance of flow-sensitive species (such as *Chiloglanis anoterus*). Pool and marginal species will continue to survive and will dominate the fish assemblages. In the Lowveld Zone (LZ), where seasonal changes are marked, a permanent reduction in flow will result in the continued dominance of the dry season assemblage, dominated by cichlids, and the permanent reduction of cyprinids and other flow-dependent species. Lower flows in the dry winter season will result in stressed communities, no breeding and the disappearance of flow-dependent species, especially in rivers which cease to flow.

Generally, mean water temperatures will increase as flow is reduced, and there will be a shift of some of the more flow- and temperature-sensitive fish of the LZ communities further upstream.

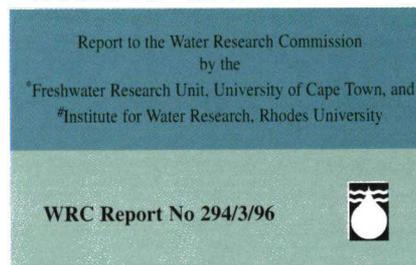


A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga with special reference to predicted impacts on the Kruger National Park

Volume Three

The effects of proposed impoundments and management recommendations

JH O'Keeffe# ● DC Weeks# ● A Fourie\* ● BR Davies\*



Report to the Water Research Commission by the

\*Freshwater Research Unit, University of Cape Town, and  
#Institute for Water Research, Rhodes University

WRC Report No 294/3/96



### □ Invertebrates

Many invertebrate species are extremely sensitive to flow conditions. During drought conditions in 1992 the average number of taxa was half that during the wetter conditions in 1990, and densities were greatly reduced. The loss of biodiversity in these circumstances is not confined to invertebrate species, since they form a crucial part of the food base for other organisms, particularly fish and amphibians, and make significant contributions to the processing of organic matter.

The change from flowing water to static conditions will also provide opportunities for the increase of those species

which favour stagnant water. These unfortunately include mosquitoes and Bilharzia host snails. The Sand River is already a centre for bilharzia transmission, but it is unlikely that the Sabie is at present.

### □ Water quality

Up to the present, reduced flows have not resulted in water quality deterioration beyond acceptable limits, except in isolated pools during drought conditions. Reduced flows will, however, result in less dilution of the effluents and irrigation return flows that reach the river. The presence of dams provides the option of making releases to dilute effluents during critical periods.

## MAINTENANCE

The researchers conclude that the maintenance of refuge areas is crucial to the continued ecological integrity of the system. From the point of view of perennial flow, the most important remaining refuge reaches in the LZ are

- the main Sabie River, which has always been perennial throughout its length, and
- the upper reaches of the Sand and Mutlumuvi tributaries.

While the most important refuge in the FHZ is the Marite River.

## MONITORING

Monitoring on the Sabie River is discussed comprehensively in Volume III. The researchers give an overview of past and present monitoring activities, and indicate supplementary monitoring required to support the future management of the Sabie-Sand River system.

Volume III of the report entitled **A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga, with special reference to predicted impacts on the Kruger National Park, Volume Three**: The effects of proposed impoundments and management recommendations (WRC Report no 294/3/96) is available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Foreign orders: Please note! US \$25 per copy of Volume III, via surface mail.)

# Status of KNP Rivers Research reported

The Water Research Commission has recently published a status report assessing the progress of the Kruger National Park Rivers Research Programme (KNPRRP). The report, entitled **Status Report on the Kruger National Park Rivers Research Programme: A Synthesis of Results and Assessment of Progress to January 1996**, was compiled by researchers J O'Keeffe and Y Coetzee.

The researchers say the purpose of the synthesis is to allow members of the Programme and all stakeholders to see what work has been done to date and how it relates to the aims of the Programme. The synthesis, however, does not aim to summarise in detail all the information that has been gathered on the rivers of the Kruger National Park, but it does indicate what work has been done, at what level of detail, and how far the aims of the Programme have been achieved.

Therefore the specific aims of the report are:

- to examine and summarise the information collected within the Programme;
- to relate the resulting synthesis to the objectives of the KNPRRP;
- to draw conclusions as to how far the objectives of Phase One have been met;
- to make recommendations with regard to remaining priority objectives that need to be addressed in the future; and to assess how far the information collected within the Programme can contribute to the setting of interim instream flow requirements.

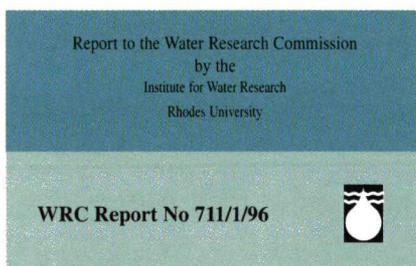
The structure of the Programme, which is based on a decision support system, is summarised in figure 1. From this it can be seen that the research and information gathering has been carefully targeted to provide essential information to assist in management decision making.

The main part of the report is given as short reviews of each component of the Programme which deals with the purpose, tasks, progress, evaluation, main products and data sets, as well as other relevant documents on each component.



Status Report on the Kruger  
National Park Rivers Research  
Programme:  
A Synthesis of Results and  
Assessment of Progress to  
January 1996

J O'Keeffe ● Y Coetzee



Report to the Water Research Commission  
by the  
Institute for Water Research  
Rhodes University

WRC Report No 711/1/96



The synthesis is based primarily on the KNPRRP Data Catalogue, which is the most comprehensive reference work on the rivers of the Kruger National Park. The data catalogue includes references from all the projects that have contributed to the knowledge, information and methods required to achieve the goals of the KNPRRP, including those which were begun before the Programme started, and those which were developed outside (but running alongside) the Programme. The authors acknowledge the important contributions made by projects outside the Programme to an understanding of the rivers of the Kruger National Park.

The final section of the report summarises the achievements of the

Programme in relation to its goals and tasks, listing the main products and expertise that has emerged, and identifies the remaining gaps and priorities for further research.

One of the outstanding achievements of the KNPRRP is the development of a multi-disciplinary, multi-institutional research management team which has contributed substantially to the understanding of fundamental environmental processes in rivers. Furthermore a decision support system has been developed which can provide users with an information pathway to assist in management decisions, or to explain and motivate environmental water use.

Amongst other achievements mentioned in the report are:

- catchment studies which have been completed for all the main rivers, describing land-use, present development of water use, probable future demand and possible scenario's for supply;
- detailed inventories and the status of the following components in the Sabie River: riparian vegetation, fish, invertebrates, large aquatic animals, geomorphological units/ sediment transport, water quality, hydrology and hydraulics.
- the availability of first estimates of environmental water requirements for all major rivers in the Kruger National Park.

The report entitled **Status Report on the Kruger National Park Rivers Research Programme: A Synthesis of Results and Assessment of Progress to January 1996** (WRC Report 711/1/97) is available from the Water Research Commission, PO Box 824, Pretoria 0001. Foreign orders please note: US \$20 per copy via surface mail.

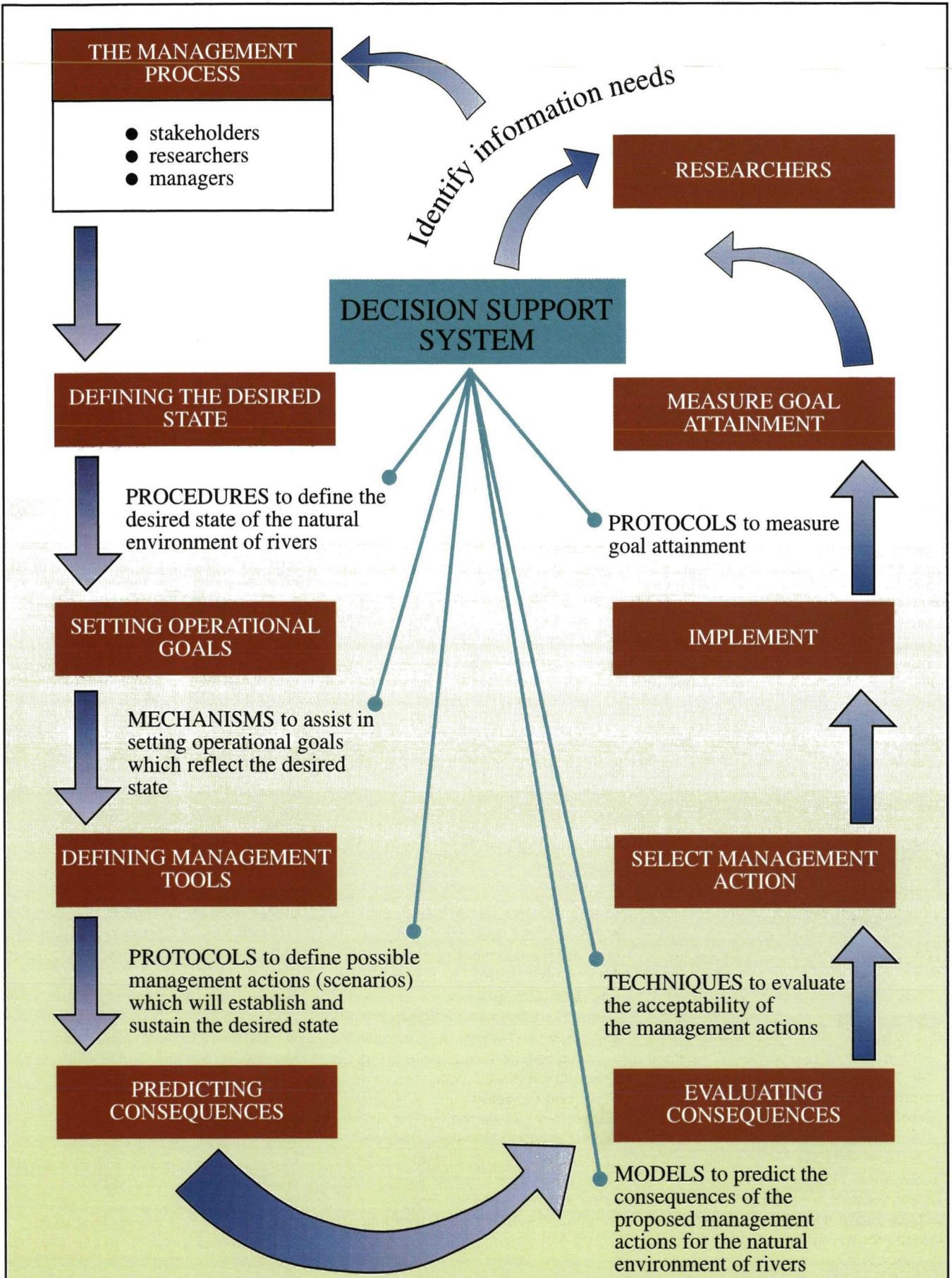


Figure 1. Elements of the Decision Support System and their relationship to the Programme management process.

# Hydrologists assemble in Morocco

A small delegation of six South African hydrologists attended the 5th Scientific Assembly of the IAHS in Rabat, Morocco, during April 1997.

After a somewhat shaky start with the transport arrangements, small buses arrived at hotels like clockwork. Presentations were all strictly on time. The Conference was well attended and produced some excellent presentations and especially in some of the workshops new ground was covered.

It was the first time in my experience at IAHS conferences that a lot of attention was paid to the application of hydrological science in water management. South African research and development in the hydrological sciences, as judged from the various presentations, is well on track and taking into account the relatively small group of dedicated hydrologists in South Africa we can be justifiably proud of our achievements. The rest of southern Africa was unfortunately poorly represented.

The African Association of Hydrologists (AAH) was officially launched; the regional office bearers are as given alongside.

A constitution and mission statement are in the process of development and I hope to keep you informed about developments! The WRC has offered assistance to AAH in setting up a web page for the rapidly emerging electronic network in Africa.

*Hugo Maaren*



**Please note:** We were informed at the General Assembly that the IAHS is heading for bankruptcy. A membership fee will most probably have to be introduced in the near future.



*The South African delegation in Morocco: Hugo Maaren, Simon Lorentz, Dennis Hughes, Bennie Haasbroek and Roland Schulze. (Absent: Mike Silberbauer)*

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## ASSOCIATION AFRICAINE D'HYDROLOGIE AAH AFRICAN ASSOCIATION OF HYDROLOGY

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# GROUNDWATER HARVEST POTENTIAL OF THE REPUBLIC OF SOUTH AFRICA

The first attempt to provide quantitative information on sustainable rates of groundwater abstraction in South Africa on a country-wide basis.

Prepared by the Directorate: Geohydrology, Department of Water Affairs and Forestry.

## The single A0 MAP SHEET COMPRISES:

### MAIN MAP:

The maximum volume of groundwater that may be abstracted per square kilometre per annum without depleting the aquifers. Harvest Potential was determined from groundwater recharge and groundwater storage. (Scale 1 : 3 000 000)

### 3 INSET MAPS:

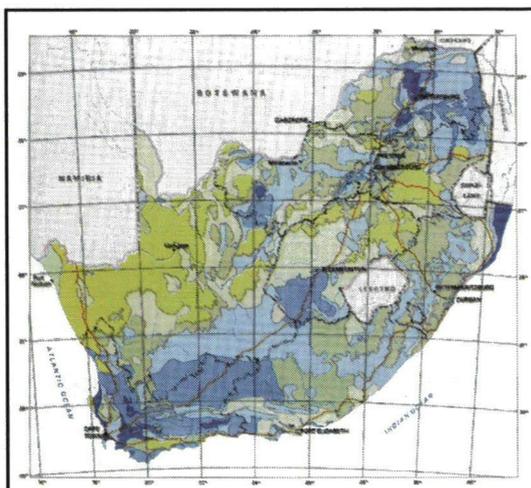
- Factors restricting Available Harvest: (Average annual recharge, variability of recharge, or volume of effective storage) (Scale 1 : 8 500 000)
  - Mean Borehole Yields (Scale 1 : 8 500 000)
  - Electrical Conductivity (Scale 1 : 8 500 000)

### TEXT:

A concise account of the determination of Harvest Potential, the applicability of the map, and a comparison of Harvest Potential with Exploitation Potential.

### PLEASE NOTE:

Harvest Potential gives the *maximum* rate at which groundwater can be sustainably abstracted. Local socio-economic or environmental factors could reduce this considerably. This map is intended to provide a national overview and perspective on sustainable abstraction. It cannot be used for local planning, development or management of groundwater. Such exercises require local investigations and assessments.



### Price:

R30.00 per map  
(VAT, postage and packing included)

Copies of the map are obtainable from:  
Ms. M. van Wyk  
Department of Water Affairs and Forestry  
Directorate: Geohydrology  
Private Bag X313  
Pretoria  
0001

Tel: (012) 338 7849  
E-mail: WB3@dwaf.pwv.gov.za

# Developing a South African aquifer classification system

**A** need for a South African aquifer classification system has existed for some time, says a researcher from the Groundwater Programme at Watertek, CSIR, Roger Parsons, in a report to the Water Research Commission (WRC). The report emanates from a project jointly funded by the WRC and the Department of Water Affairs and Forestry in which such a classification system has been created. Parsons says the classification system is required to promote sound and consistent decision-making related to groundwater matters and, more specifically, to provide a framework to support the groundwater quality management strategy currently being developed by the Department.

According to the report a literature study of classification systems used elsewhere in the world was undertaken. The study was supported by a series of scoping workshops at which the desired features and characteristics were discussed. A proposed classification was then developed and presented to a technical workshop for discussion after which the final classification was formulated.

The aquifer system management classification developed during the study is based on the British Geological Survey aquifer vulnerability classification, but also recognises the need to consider two important management aspects, namely:

- the high value of sole source aquifers in South Africa, and
- the need for a pragmatic approach which allows for special factors to be considered.

The report says it was also recognised that a single classification could not meet all needs and that modifications would be required for specific tasks. A flexible decision-support tool was hence developed which relates the aquifer system management classification to a user defined variable by means of a simple weighting and rating approach.

Using this decision-support tool, a Groundwater Quality Management classification was developed. The aquifer

system management classification was linked to an aquifer vulnerability classification in order to define the level of protection required in a particular area. The Groundwater Quality Management classification can therefore be used to support the national Groundwater Quality Management Strategy.

The process of implementing the classification still needs to be addressed as do the implications of adopting the approach. It is recommended that a national scale classification map be prepared and distributed as a means of gaining widespread support for the aquifer system management classification and the associated decision support tools.

The classification system presented is a useful planning tool that provides a starting point for national and regional

classification of South Africa's aquifers. It is unlikely that the Groundwater Quality Management classification can be used for site specific applications. The proposed classification is not, however, cast in stone and, as available information and knowledge grows and the national Groundwater Quality Management Strategy evolves, so too will the need to extend or modify the aquifer classification. A degree of flexibility needs to be applied when classifying aquifers to accommodate our limited knowledge and the precautionary principle.

Copies of the report entitled **A South African aquifer system management classification** (WRC report KV 77/95) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 15-00, via surface mail).

AQUIFER SYSTEM MANAGEMENT CLASS	DEFINITION
<b>Sole source aquifer system</b>	An aquifer that supplies 50% or more of domestic water for a given area, and for which there are no reasonably available alternative sources, should the aquifer be impacted or depleted.
<b>Major aquifer system</b>	Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150mS/m).
<b>Minor aquifer system</b>	These can consist of fractured or potentially fractured rocks that do not have a high primary permeability, or other formations of variable permeability. Although these aquifers seldom produce large quantities, of water, they are important for both local supplies and to supply base flow for rivers.
<b>Non-aquifer system</b>	These are formations with negligible permeability, which generally do not contain groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flows through such rocks, although imperceptible, do take place, and need to be considered when assessing the risks associated with persistent pollutants.
<b>Special aquifer system</b>	An aquifer designated as such by the Minister of Water Affairs and Forestry, after due process.

# Common communication currency developed for researchers

“Integrated catchment management cannot be founded on disintegrated science. The basis of sound integration is good communication and the basis of that communication is a sound knowledge of the subject matter to be conveyed as well as and a recognition that the process of communication is as important as the content of that communication”, say researchers JDJ van Rensburg and MC Dent in a project report to the Water Research Commission.

The project **Development of a Water Quality and Quantity Modelling System which will provide a Common Currency for Communication between Researchers in the Kruger National Park Rivers Research Programme** (KNPRRP) has succeeded in providing a structured and operational form of communication between the research groups within the KNPRRP, both at the conceptual and technical level.

This project was initiated within the framework of the Training, Information and Technology Transfer (TITT) Sub-Programme of the Kruger National Park Rivers Research Programme. The aims of the project were:

- to develop (for the Sabie River) the framework of a modelling system which incorporates *inter alia* ARC/INFO, HSPF and the Watershed Data Management System (WDMS), into a flexible, versatile and professional tool.
- to demonstrate that the product of the above development can serve as a catalyst to elicit more meaningful interaction, communication, and ultimately integration, than is presently the case amongst researchers in the KNPRRP.
- to empower the teams of researchers who are seeking to integrate their work on the KNPRRP, to embark

on an informed search for a better modelling system at some future time when they are well able to communicate at the detailed scientific levels required by a programme of this nature.

## COLLABORATION

It was evident that the Training, Information and Technology Transfer (TITT) sub-programme would have to work very closely with the Decision Support System Development and Management (DSSDM) sub-programme of the KNPRRP, and that most of the training, information, communication and technology transfer work required of the sub-programme would have to be channelled through modelling systems, developed with or within the other KNPRRP sub-programmes.

Development of a Water Quality and Quantity Modelling System which will Provide a Common Currency for Communication between Researchers in the Kruger National Park Rivers Research Programme

JDJ van Rensburg • MC Dent

Report to the Water Research Commission by the Department of Landscape Architecture University of Pretoria

WRC Report No 654/1/97



The modelling and graphical presentation systems which are the subject of this report are designed to address both the internal and external communication and to provide a common currency for communication on major aspects of the KNPRRP programme.

## TECHNICAL CRITERIA

The criteria for the technical approach in this project clearly had to include a backbone modelling system to provide continuity and cohesion for the time series involved in the abiotic simulation portion of the programme. The chosen system had to meet the following criteria:

- a sound time series management system, which is of prime importance;
- simulate at daily time step, and preferably smaller time steps if required (this is not to imply that all the ecosystem processes need to be simulated at daily time steps, it is simply the smallest pragmatic time step and all larger time steps can be achieved by aggregation from this base);
- simulate water quantity and quality at a range of spatial scales;
- models included in the hydrological (abiotic) simulation system should be based on physical processes as far as possible, and be specifically able to simulate *inter alia* forestry, irrigation and dryland agriculture;
- modelling software should be currently available, and
- utilities to support those backbone models are important;
- that the system does model the core hydrology, hydraulics, erosion and sedimentation and water quality at an acceptable level for initial purposes;
- that the system of models covers both land and instream processes;
- that the networking of a complex web of time series flows and fluxes is accommodated;
- that in the abovementioned areas, the chosen system has an international

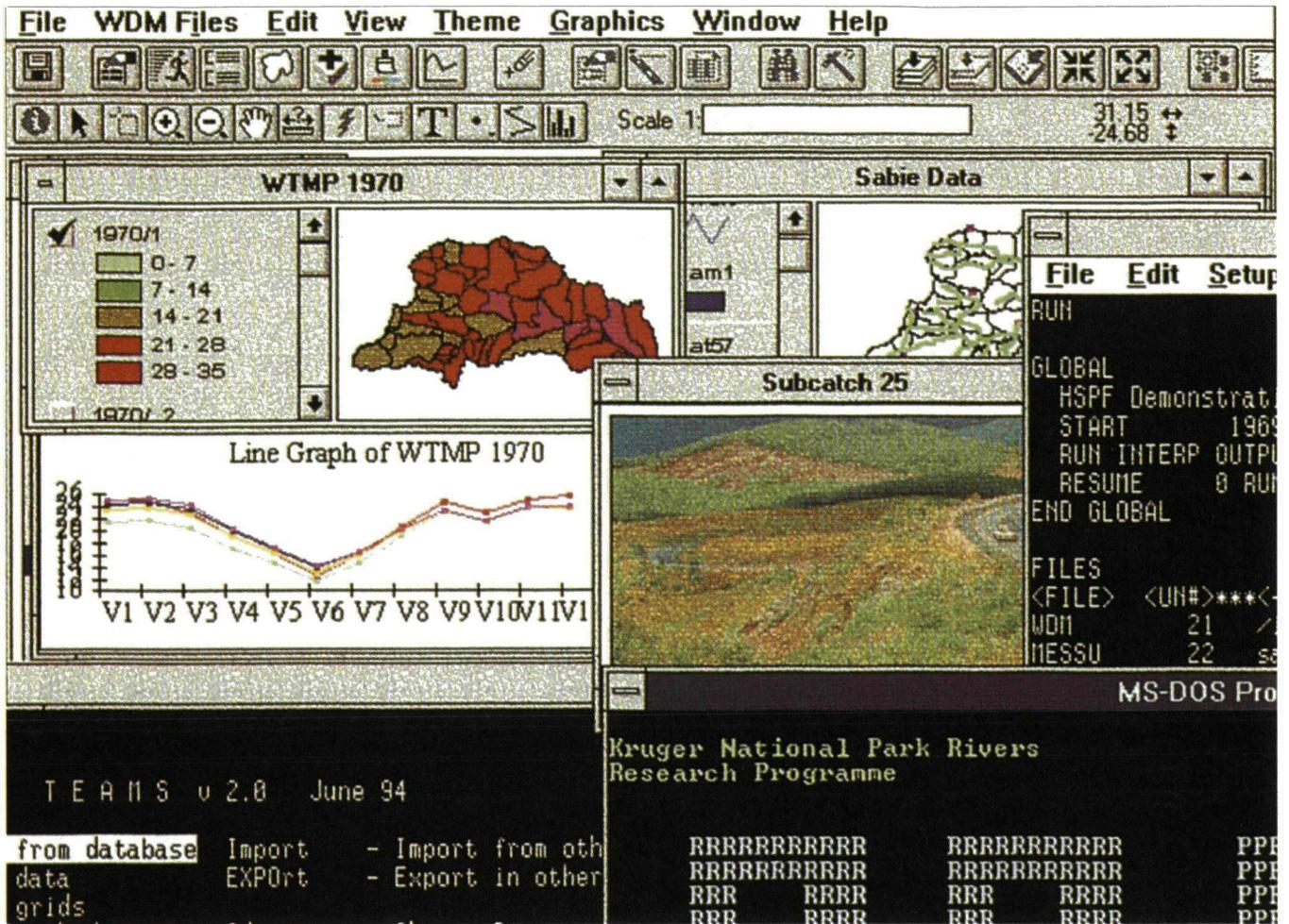


Figure 1. A computer screen image illustrating the focal point of the methodology described in the report.

record of success and continuing endeavour in providing a common currency for communication in complex integrated catchment management systems, and

- the systems should be documented, stable, affordable, changeable, credible and supported at reasonable cost.

The Hydrological Simulation Program Fortran (HSPF) and the ACRU agro-hydrological modelling system were selected, since they met the above criteria. The attributes of the ACRU model are well known to South Africa. The HSPF system which was developed for the United States Environmental Protection Agency (EPA), is widely used and is readily linked to other models through the WDMs. Furthermore, the time series manipulation and display capability of software developed by Ninham Shand Inc. were adopted and used in this development project.

**METHODOLOGY**

Extensive effort was expended on the GIS and climatic data set (at the daily level) from 1930-1994. These are now included in the modelling system and the accompanying WDMGUIDE software system which is used to view the GIS and model simulated information. The WDMGUIDE, which is based on the Arcview2 system, is one of the main products of this project.

The Sabie catchment was divided into 57 sub-catchments, so that the HSPF and ACRU models could run the simulation system in a distributed fashion. The output from the hydrological simulations from the ACRU model were linked with the stream channel simulation routines of the HSPF model via the WDMs. In the reaches of the Sabie River within the KNP, the sub-catchment boundaries in the KNP were chosen to enable the hydrological simulations to provide information at the 31 locations at which the University of the

Witwatersrand's Centre for Water in the Environment (CWE) researchers had been studying morphometry, sedimentation and riverine vegetation in detail.

A subset of the Ninham Shand suite of time series analysis and plotting programmes were prepared to present the output from the HSPF and ACRU simulations. This software now operates on a PC simultaneously with, but independent of, the WDMGUIDE.

When operated in a multi-tasking windows environment this offers the user substantial flexibility and functionality.

**OPERATION**

The DOS based interactive digital version of the DATA CATALOGUE developed by the KNPRRP's Information Systems Development and Management (ISDM) sub-programme is also running on the same computer. The net result is that the user of the system developed and integrated during the

course of this project has all the above-mentioned capabilities and the ability to run simultaneous sessions at one or more remote UNIX based sites on the Internet. The user is thus now able to switch between these systems, literally at the flick of a "mouse" button. Several photographic images have also been included in the software. At present these are for purposes of illustrating a concept, however, many more images could be inserted, which would considerably enhance the communication power of the system.

### CONCLUSION

The TITT sub-programme is now in a position to offer, geographically scattered groups, the ability to simultaneously view, manipulate and analyse the same information. Such information can be text, numerical or graphical. Further tools have been developed to view the time dependent data in temporal and spatial context. Such facilities will substantially enhance the tempo and synergy which can be applied to the situation. The technology developed in this project is capable of achieving this in a most cost effective manner. Furthermore, through this project the TITT sub-programme has acted as a catalyst to secure a growing commitment from a range of scientists to work together on these developments in such a way that the established expertise base of each group is not threatened, while creating a cost effective and non-intrusive way to interface the work of each group.

The project has also served as the focal point and interface for developing links between the KNPRRP and many institutions, both nationally and internationally.

The report **Development of a Water Quality and Quantity Modelling System which will Provide a Common Currency for Communication between Researchers in the Kruger National Park Rivers Research Programme** (WRC Report 654/1/79) is available free of charge from the Water Research Commission, PO Box 824 Pretoria 0001. Foreign orders: US \$20 per copy via surface mail.

# NEW ICOLD PUBLICATIONS RELEASED

The International Commission on Large Dams, ICOLD, recently released a number of publications. ICOLD was originally established to encourage advances in the design, construction, operation and maintenance of large dams through the collection and dissemination of information and stimulation of research.

The most recent publications are:

- ❑ Bulletin 100: Dams and Environment Ridracoli: A model achievement. This new report describes a case history of the Ridracoli Dam project in Italy, designed and built with a view to making works and reservoir blend into the natural, cultural and socio-economic environment.
- ❑ Bulletin 101: Tailing Dams - Transport, placement and decantation - Review and recommendations. This is a review of the various methods of transport of tailings from prime source to placement at the disposal site and the design and closure conditions of the decant systems.
- ❑ Bulletin 102: Vibration of Hydraulic Equipment for Dams - Review and recommendation. The bulletin addresses designers, manufacturers and owners who will greatly benefit from the comprehensive review presented.
- ❑ Bulletin 103: Tailings Dams and Environment - Review and recommendations. This is a unique review for all those involved with environmental issues in relation to tailings dams.
- ❑ Bulletin 104: Monitoring of Tailings Dams - Review and recommendations. The bulletin is devoted to monitoring of dams of this type whose design, structure, technique, period of construction differ from conventional fill dams retaining water.
- ❑ Bulletin 105: Dams and related structures in cold climate - Design guidelines and case studies. This publication reviews the problem experienced in cold climate and presents preventive measures.
- ❑ Bulletin 106: A guide to Tailings Dams and Impoundments - Design, construction, use and rehabilitation. This bulletin focuses on the correct management of mine and industrial tailings.

These publications are available from the South African Committee of the International Commission of Large Dams, (Sancold). Sancold promotes among its members an interchange of information regarding large dams, maintains a register of large dams in South Africa for incorporation in the world register of large dams, participates in meetings, congresses and tasks allotted to committees by Icold.

### Enquiries to:

**Sancold Treasurer, PO Box 3404, PRETORIA, 0001, Fax: (012) 326-2630.**

# SA WATERKALENDER

The Water Research Commission publishes this calendar 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  
E-mail: jan@wrc.cwv.ac.za

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.

## 1997

<b>JANUARY</b>  S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	<b>FEBRUARY</b>  S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	<b>MARCH</b>  S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	<b>APRIL</b>  S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
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Die Waternavorsingskommissie plaas hierdie kalender om te help met die koördinerings 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  
E-pos: jan@wrc.cwv.ac.za

Gids:

- Een SA Watergeleentheid vir hierdie dae.
- 'n Tweede SA Watergeleentheid vir dié datums.
- 'n Derde SA Watergeleentheid vir dié datums.

Sien Konferensies- en Simposiumbladsy vir aangeduide geleentheid.

## 1998

<b>JANUARY</b> S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	<b>FEBRUARY</b> S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	<b>MARCH</b> S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	<b>APRIL</b> S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
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SOUTHERN  
AFRICA

1997

## WEDC '97

SEPTEMBER 1 - 5

The 23rd WEDC conference will be held at the International Convention Centre in Durban. Theme: Water and sanitation for all.

Enquiries: Conference Secretariat, Congress International, 18 Rapson Road, Morningside 4001, Durban. Tel: (031) 233-494. Fax: (031) 232-405. E-mail: ci@neptune.infolink.co.za

ENVIRONMENTAL  
MANAGEMENT

SEPTEMBER 8 - 10

An IAWQ specialised conference on Chemical process industries and environmental management will be held at the new four-star Table Bay Hotel, Waterfront, Cape Town.

Enquiries: Conference Secretariat: Ms Ammie Wissing, Conference Planners, PO Box 36782, Menlopark 0102. Tel: (012) 348-4493. Fax: (012) 348-1563. E-mail: Wissing@iafrica.com

## ENVIRONMENT

SEPTEMBER 8 - 11

An international conference on health and environment in Africa will be held at the CSIR Conference Centre in Pretoria.

Enquiries: The Conference Secretariat, 18 Rapson Road, Morningside, Durban 4001. Tel: (031) 233494. Fax: (031) 232405.

## SAICE LECTURE

SEPTEMBER 10

As part of the SAICE evening lecture programme, Mr Martin van Veelen will give a lecture on "The determination of in-stream water quality management objectives" at 17:15 at the Jeffrey Auditorium, St John's College, St David's Road, Houghton.

Enquiries: Mrs Carol Zabora. Tel: (012) 666 7175. Fax: (011) 475-2090/(012) 666-7177. E-mail: g5design@global.co.za

## AQUACULTURE

SEPTEMBER 15 - 18

The 4th congress of the Aquaculture Association of

Southern Africa with the theme: Aquaculture - an opportunity based on science and technology will be held in Stellenbosch. Enquiries: The Chairman AASA Congress, Mr TT de Villiers, Department of Agriculture, Elsberg 7607. Tel: (021) 808 5017. Fax: (021) 808 5120. E-mail: dier5@elsburg1.agric.za

## WATER AFRICA '97

SEPTEMBER 15 - 19

The second Southern Africa Water & Wastewater conference and exhibition will be held in Harare, Zimbabwe. Theme: "Water security: guarding resources against drought and pollution".

Enquiries: Zia Howeson. Tel: (011) 792-9807. Fax: (011) 791-0571.

## SEWAGE PLANTS

OCTOBER 6 - 10

A post-graduate training course in water utilisation: Operation of small water purification and sewage plants will take place in Pretoria.

Enquiries: The Head, Water Utilisation Division, University of Pretoria, Pretoria 0002. Fax: (012) 43-6683. E-mail: dtaih@fanella.ee.up.ac.za

MEMBRANE  
TECHNOLOGY

OCTOBER 21 - 24

The second WISA-MTD workshop and seminar will be held at the Aventura Badplaas resort in Mpumalanga. Theme: Membranes in your industry.

Enquiries: Dr Ed Jacobs (secretary - WISA-MTD), Institute of Polymer Science, University of Stellenbosch, PO Matieland, Stellenbosch 7602. Fax: (021) 808-4967. Tel: (021) 808 3178. E-mail: epj@land.sun.ac.za

## HYDRAULICS

NOVEMBER 5 - 7

The third in the series of international River Flood Hydraulics conferences will be organised by HR Wallingford in partnership with the University of Stellenbosch at Stellenbosch. Topics to be covered include flood hydraulics and hydrology, management of developments on flood plains, flood control, sediment transport and river morphology, flow measurement: social, economic and environmental aspects.

Enquiries: Prof A Rooseboom, University of Stellenbosch. Tel:

(021) 808-4353. Fax: (021) 808-4361.

## DAM DESIGN

NOVEMBER 3 - 4

A course on the design of smaller dams will be offered under the auspices of SANCOLD at the University of Stellenbosch.

Enquiries: Prof A Rooseboom, University of Stellenbosch. Tel: (021) 808-4353. Fax: (021) 808-4361.

## HYDROLOGY

NOVEMBER 17 - 19

The SANCIAHS/SAICE '97 conference will be held at the University of Pretoria. Theme: Integrated hydrological sciences for sustainable water resources management in Africa.

Enquiries: Ms Gerda Kruger, Water Research Commission, PO Box 824, Pretoria 0001. Tel: (012) 330-0340. Fax: (012) 331-2565. E-mail: gerda@wrc.ccwr.ac.za

## WATER &amp; SANITATION

DECEMBER 1 - 5

A conference on standard setting, quality control and coordination for training in the water and sanitation sector will be held in the Gauteng Province. **Call for papers.**

Enquiries: The Coordinator: ITN Africa Conference, PO Box 95557, Waterkloof, Pretoria 0145. Tel/Fax: (012) 46-5453.

1998

## CEMSA '98

FEBRUARY 9 - 11

An international conference and exhibition on Integrated Environmental Management (IEM) in South Africa will be held in East London.

Enquiries: Professor OS Fatoki, University of Fort Hare, Analytical Chemistry, Private Bag X1314, Alice 5700. Tel: 404-22094. Fax: 404-31643. E-mail: FATOKI@UFHCC.UFH.AC.ZA

## WISA '98

MAY 4 - 7 1998

The biennial conference and exhibition of the Water Institute of Southern Africa (WISA) will be held in Cape Town. **Call for papers.**

Enquiries: Conference Planners, PO Box 36782, Menlo Park 0102. Tel: (012) 348-4493. Fax: (012) 348-1563. E-mail: wissing@iafrica.com

## OVERSEAS

1997

## SEDIMENTS

SEPTEMBER 7 - 11

An international conference on contaminated sediments will be held in Rotterdam, the Netherlands.

Enquiries: Van Namen & Westerlaken Congress Organisation Services, PO Box 1558, 6501 BN Nijmegen, The Netherlands. Tel: +31 24 323 44 71. Fax: +31 24360 1159.

## IRRIGATION

SEPTEMBER 8 - 12

The 48th meeting of the International Executive Council of the International Commission on Irrigation and Drainage (ICID) and the 18th Regional Conference on Irrigation and Drainage will be held in Oxford, England.

Enquiries: Oxford Conference Management, 10b Littlegate Street, Oxford. OX1 1QT, United Kingdom.

## IWSA

SEPTEMBER 20 - 26

The 21st International Water Supply Association (IWSA) world congress and exhibition will be held in Madrid, Spain.

Enquiries: IWSA, 1 Queen Anne's Gate, London SW1H 9BT, United Kingdom. Fax: +44 (0) 171 222 7243. Tel: +44 171 957 4567. E-mail: IWSA@diai.pipex.com

## HYDROLOGY

SEPTEMBER 21 - 27

The 27th International Association of Hydrological Sciences Congress will take place in Nottingham, UK. Theme: Groundwater in the urban environment.

Enquiries: IAHS, Nottingham, United Kingdom. Fax: 0115 985 6612. Tel: 0115 985 6545.

CATCHMENT  
MANAGEMENT

SEPTEMBER 23 - 25

A seminar and workshop on integrated catchment and watershed management will be held at the University of New England in Australia.

Enquiries: John Pigram, Centre for Water Policy Research, University of New England,

Armidale, NSW 2351 Australia.  
Tel: 067 73 2420. Fax: 67 733  
327. E-mail: jpigram@metz.une.  
edu.au

### HYDROLOGY

SEPTEMBER 25 - 27  
An international symposium on emerging trends in hydrology will be held in Roorkee, India.  
Enquiries: Dr DC Singhal, Professor and Organising Secretary (ISETH), Department of Hydrology, University of Roorkee, Roorkee-247667, India. Tel: (091) 1332 72349 (ext 336). Fax: (091) 1332-73560. E-mail: hydro@rurkiu.ernet.in

### HYDROLOGY

SEPTEMBER 29 - OCTOBER 1  
The second national conference on integrated catchment management: advancing integrated resource management - processes and policies will be held in Canberra, Australia.  
Enquiries: ICM, 16 Larch Crescent, Mt Waverley Vic. 3149, Australia. E-mail: rbms@vicnet.net.au Fax: +61 3 9802 2315.

### HYDROLOGY

SEPTEMBER 30 - OCTOBER 3  
The 3rd international conference on FRIEND: regional hydrology - concepts and models for sustainable water development will take place in Postojna, Slovenia.  
Enquiries: Ljubljana, Slovenia. Fax: 386 61219 987. E-mail: mitja.brilly@uni-lj.si Tel: 386-61-1254-333.

### LANDFILL

OCTOBER 13 - 17  
The sixth International Landfill Symposium will be held in Cagliari, Sardinia, Italy.  
Enquiries: Ms Anne Farmer, CISA - Environmental Sanitary Engineering Centre, Via Marengo 34 - 09123 Cagliari (Italy). Tel: +39-70-271652. Fax: +39-70-271371. E-mail: cossur@vaxca3.unica.it

### DRINKING WATER

OCTOBER 16 - 19  
An international conference on the management of drinking water resources will take place in Madras, India.  
Enquiries: M Mariappan, Organising Secretary, Central Leather Research Institute, Adyar, Madras 600 020, India. E-mail: root@niclai.ernet.in Fax: 91 044 4911589. Tel: 91 044 4916351.

### WEFTEC '97

OCTOBER 18 - 22  
The American Water Environment Federation's 70th annual conference and exposition will be held in Chicago, Illinois USA.  
Enquiries: WEFTEC '97 Program, 601 Wythe Street, Alexandria, Virginia 22314-1994 USA. Tel: 1-703-684-2452 Fax: 1-703-684-2471.

### OZONE

OCTOBER 26 - 31  
The 13th world congress of the International Ozone Association will be held in Kyoto, Japan.  
Enquiries: Congress Corporation. Tel: +81 (6) 454 3740. Fax: +81 (6) 454 4711.

### LAKES

OCTOBER 27 - 31  
The 7th ILEC international conference on the conservation and management of lakes will be held in San Martin de los Andes, Argentina.  
Enquiries: Instituto Nacional de Ciencia y Tecnica Hidricas, CC No 46, 1802 Aeropuerto Ezelza, Prov. de Buenos Aires, Argentina. Tel: +54 1 480 0867. Fax: +54 1 480 0094.

### IWEX '97

The international water and effluent treatment exhibition, IWEX '97, will be held in Birmingham, UK.  
Enquiries: Tom Tebbat, Exhibition Director, Turret Group Plc, 171 High Street, Rickmansworth, Herts, WD3 1SN, United Kingdom. Fax: +44 1932 221346. Tel: +44 1932 228577.

1998

### WATER QUALITY

FEBRUARY 25 - MARCH 1  
The first international specialised conference on water quality and its management will be held in New Delhi, India.  
Enquiries: CVJ Varma, Central Board of Irrigation & Power, Malcha Marg, Chanakyapuri, New Delhi 110021, India. Tel: +91 11 3015984. Fax: +91 11 3016347. E-mail: cbip@cbipdel.uunet.in

### CHLORINATED COMPOUNDS

MAY 18 - 21  
The first international conference on remediation of chlorinated and

recalcitrant compounds will be held in Monterey, California, USA.

Enquiries: The Conference Group, 1989 West Fifth Avenue Suite 5, Columbus, Ohio 43212-1912 USA. Tel: 614-424-5461. Fax: 614-488-5747. E-mail: 102632.3100@compuserve.com

### MEMBRANE SCIENCE

JUNE 9 - 12  
An international conference on membrane science and technology (ICMST '98) will be held in Beijing, China.  
Enquiries: Mrs Yanqiao Shi, ICMST'98, c/o Institute of Chemistry, Chinese Academy of Sciences, Zhongguancun, Beijing 100080, China. Fax: +86-10-62569564 OR: 62559373.

### IAWQ

JUNE 21 - 26  
The 19th biennial conference of the International Association on Water Quality will be held in Vancouver, BC Canada.  
Enquiries: IAWQ, Duchess House, 20 Mason Yard, Duke St., St James's, London SW1Y 6BU, United Kingdom. Tel: 44 (0) 171-839 8390. Fax: 44 (0) 171-839 8299.

### GROUNDWATER

JULY 12 - 16 1998  
An international conference with the theme Future groundwater resources at risk, will be held in Changchun, China.  
Enquiries: Professor Lin Xueyu, Changchun University of Earth Sciences, Changchun, Jilin 130 026, China. Fax: 86 431892 8327.

### CLIMATE & WATER

AUGUST 17 - 20  
The second international conference on climate and water will be held in Espoo, Finland.  
Enquiries: Risto Lemmela, HUT/Water Res. Eng., Huhtatie 12, 04300 Tuusula, Finland. Tel: +358 9 275 3835. Fax: +358 9 451 3827. E-mail: rlemmela@ahti.hut.fi

### WATERSHED MANAGEMENT

SEPTEMBER 7 - 10  
An international symposium on comprehensive watershed management (ISWM-'98) will be held in Beijing, China. Call for papers.  
Enquiries: Mr Tan Ying, IRTCES, PO Box 366, Beijing 100044, China. Tel: +86-10-68413372. Fax: +86-10-68411174. E-mail:

irtces@public2.bta.net.cn

### TISAR '98

SEPTEMBER 21 - 25  
The third international symposium on artificial recharge of groundwater will be held in Amsterdam, the Netherlands.  
Enquiries: Symposium Secretariat, Buerweg 51, 1861 CH Bergen, the Netherlands. Tel: +31 72 5899062. Fax: +31 72 5899040. E-mail: R.R.Kruize@inter.nl.net

### GROUNDWATER

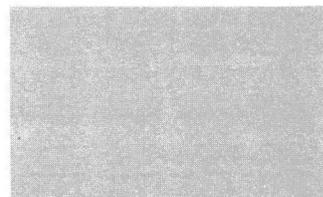
SEPTEMBER 21 - 25  
An international conference and special workshops on groundwater quality: remediation and protection (GQ 98) will be held in Tübingen, Germany.  
Enquiries: Conference Secretariat GQ'98, c/o Lehrstuhl für Angewandte Geologie, Sigwartstr 10, D-72076 Tübingen, Germany. Tel: +49 (0) 7071-297-4692 OR: 297-6468. Fax: +49 (0) 7071-5059. E-mail: mike.herbart@uni-tuebingen.de

### WATER RESOURCES

NOVEMBER 16 - 19  
An international conference on water resources variability in Africa during the 20th century will take place in Abidjan, Ivory Coast. **Call for papers.**  
Enquiries: Abidjan '98 ORSTOM, 06 BP 1203 Cidex 1, Abidjan 06, Côte d'Ivoire. Tel: (225) 45 00 74/45 41 70. Fax: (225) 45 00 76/24 65 04. E-mail: servat@orstom.rio.net OR: 101727.2773 @compuserve.com

### SEDIMENTATION

DECEMBER 16 - 18  
The 7th international symposium on river sedimentation together with the 2nd international symposium on environmental hydraulics will be held in Hong Kong. **Call for papers.**  
Enquiries: Dr AW Jayawardena, Dept. of Civil and Structural Engineering, University of Hong Kong, Pokfulam Road, Hong Kong. Fax: (852) 2559 5337. E-mail: ISRSEH98@HKUCC.HKU.HK



# UNESCO REGIONAL WORKSHOP

on

## WOMEN'S PARTICIPATION IN WATER MANAGEMENT

24 - 26 November 1997  
Pretoria, South Africa

This workshop is being organised by:

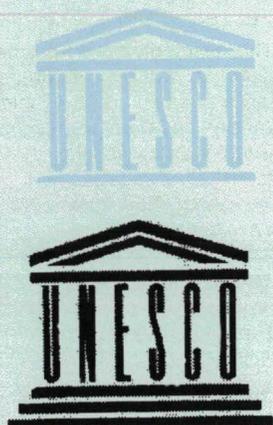
- UNESCO's International Hydrological Programme (IHP) together with
- the South African National Committee for IHP,
- and the Water Research Commission.

The main objectives of the workshop are:

- to develop strategies for improving women's participation in water management;
- to create conditions and regulations in favour of women empowerment in water resources development programmes;
- to stimulate international and regional co-operation for the exchange of information and experiences.

### Enquiries:

Dr Nozi Mjoli  
Water Research Commission  
Tel. (012) 330 0340 Fax (012) 331 2565  
e-mail: nozi@wrc.cwr.ac.za



# TECHNOLOGY TRANSFER WORKSHOP ON BIOFILTRATION AND SECONDARY CLARIFICATION

This workshop will transfer the latest technology with respect to biofiltration, both in carbon and ammonia removal. The workshop will cover both international experience in this field as well as local South African studies.

## WHEN

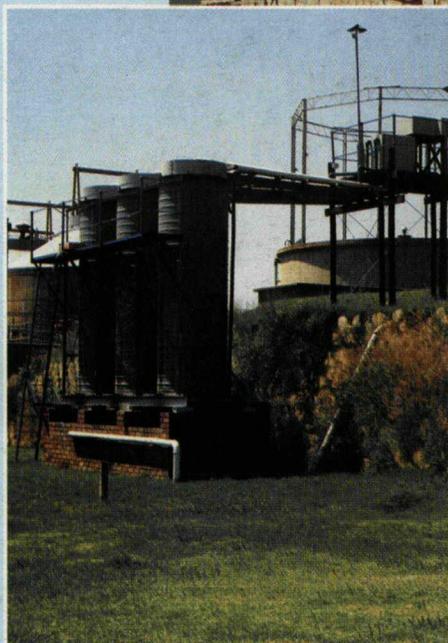
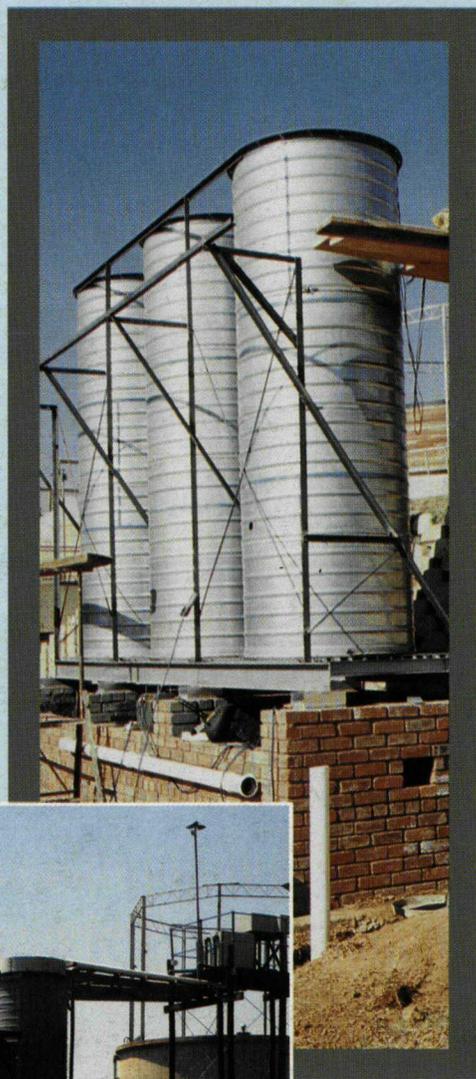
4 - 5  
November

## WHERE

Helderfontein  
Conference  
Centre,  
Kyalami

## COST

R800,00  
per person



The workshop will also present a preview of the new IAWQ STR document on the theory, modelling, design and operation of secondary settling tanks.

The workshop will be presented by international and local specialists which include Dr DS Parker of USA, Prof Cloete of the University of Pretoria, Prof Ekama of the University of Cape Town and Dr André van Niekerk of Wates, Meiring and Barnard Consulting Engineers.

## ENQUIRIES AND REGISTRATION

Ms Louisa Smit  
Tel: (011) 315-0316  
Cell: 083 306 1126  
Fax: (011) 315-0317  
E-mail: [wmb@iafrica.com](mailto:wmb@iafrica.com)