

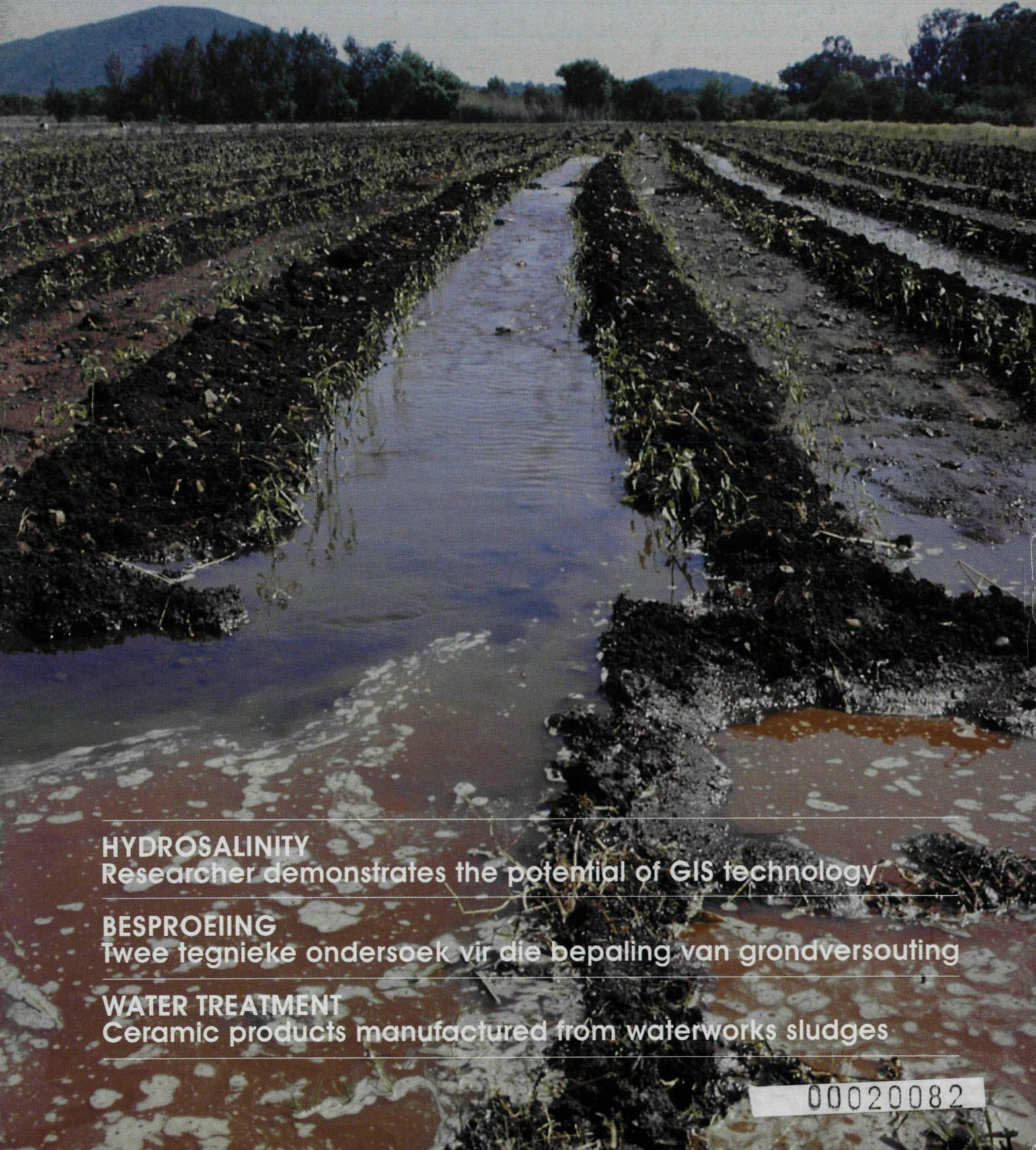
MduP.

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HYDROSALINITY

Researcher demonstrates the potential of GIS technology

BESPROEIJING

Twee tegnieke ondersoek vir die bepaling van grondversouting

WATER TREATMENT

Ceramic products manufactured from waterworks sludges

00020082

NATIONAL GROUNDWATER MAPS

The first attempt at providing synoptic and visual information on South Africa's groundwater resources

Prepared for the
Water Research
Commission by
JR Vegter

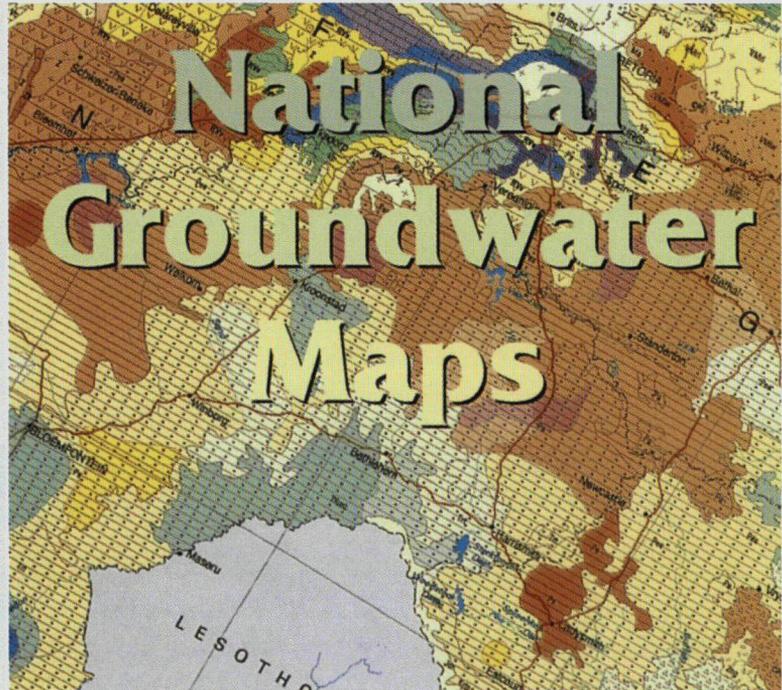
The set of hydrogeological maps has been produced on two A0 sheets as follows:

● Sheet 1:

Borehole prospects in colours superimposed on a background of lithostratigraphy indicated by different hachuring and letter symbols (scale 1:2.5 million).

● Sheet 2

- Saturated interstices providing a qualitative indication of groundwater storage (scale 1:4 million)
- Depth of groundwater level (scale 1:7.5 million)
- Mean annual groundwater recharge (scale 1:7.5 million)
- Groundwater component of river flow (base flow) (scale 1:7.5 million)
- Groundwater quality (scale 1:7.5 million)
- Hydrochemical types (scale 1:7.5 million)



A Guide on how to read and understand the maps is included. The Guide also gives a short exposition of hydrogeological principles on which the maps are based and how they were compiled.

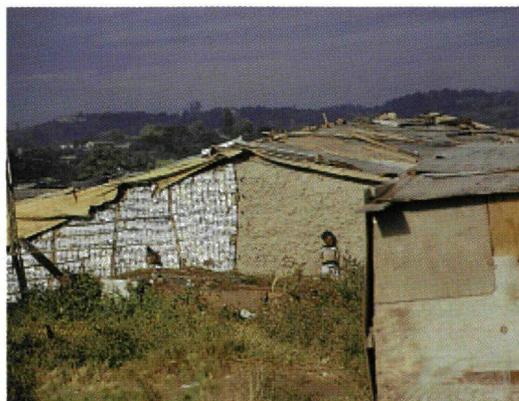
Note: It should be emphasised that these maps depict groundwater conditions on a regional scale. They are not site-specific and cannot be used for borehole siting or for deducing any other site-specific condition. Such an exercise requires local investigations and larger scale maps.

Price: R114,00 (VAT, postage and packing incl.) for a set of two maps together with the Guide. Please send payment with your order. Proforma invoices will be issued on request.

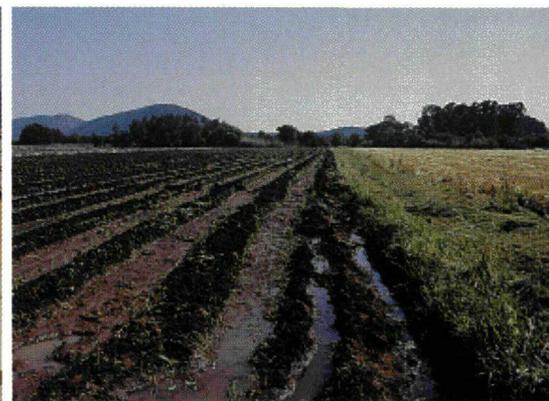
Orders: The maps are obtainable from The Librarian, Mrs Tineke van der Schyff, The Water Research Commission, PO Box 824, Pretoria 0001.



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Cover: Flood irrigation: the accumulation of salts in soil is often associated with waterlogging. (Foto: Jan du Plessis)

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

National aquatic conservation committee established



The National Aquatic Conservation Committee. The members are: Front row: (from left) Stewart Thorne, Dr Danie Coetzer, Dr Kas Hamman (Chairman) and Dean Impson (all from Cape Nature Conservation), Reichardt Viljoen (Department of Agriculture) and Leon Barkhuizen (Free State Agriculture and Environmental Affairs). Second row: Pieter van Heerden (North Western Province), Johan Watson (Free State Agriculture and Environmental Affairs), Johan Engelbrecht (Mpumalanga), Tembinkosi Tyale (Eastern Cape) and Mike Holtzhausen (Department of Agriculture). Back row: Johan Botha and Fanie Coetzee (DEAT Northern Province), Dr Ben Benade (Northern Cape Nature Conservation), Mike Coke (Natal Parks Board), Pierre de Villiers (Free State), Dr Anton Bok (Eastern Cape) and Dr Gert Willemse (Gauteng Nature Conservation).

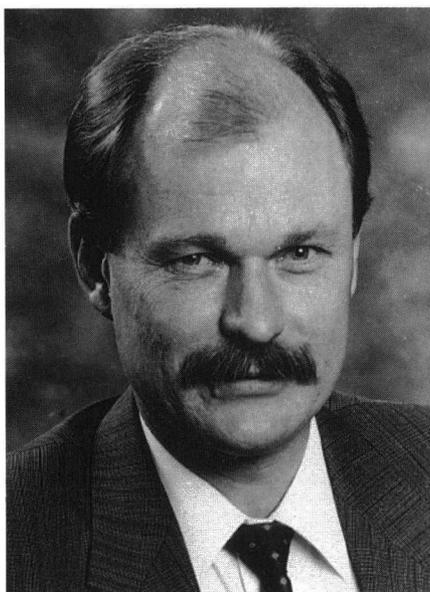
A National Aquatic Conservation Committee was established in August last year at a meeting held at the Willem Prinsloo Game Reserve in the Free State. According to Mr Mike Coke, a freshwater ecologist of the Natal Parks Board, the main purposes of the committee are to provide a national forum for the discussion of aquatic conservation, to develop a uniform inter-provincial policy on such matters and to identify issues needing research, monitoring or management. At their inaugural meeting the committee discussed import controls, wetland management, grass carp, resource utilisation, fishways and inter-basin transfers. Mr Coke says several working groups were also set up to tackle specific tasks before the next meeting in February in Mpumalanga Province.

WNK NAVORSINGSBESTUURDER VERKIES AS PRESIDENT VAN LEVSA

Dr Gerhard Backeberg, navorsingsbestuurder by die Waternavorsingskommissie, is einde 1995 tydens die jaarlikse konferensie van die Landbou-Ekonomie Vereniging van Suid-Afrika (LEVSA) as president van LEVSA verkies vir 'n termyn van twee jaar.

Die belangrikste doelstellings van LEVSA, soos deur die bestuurskomitee gestel, is volgens dr Backeberg om opleiding en navorsing in landbou-ekonomie te bevorder; om die toepassing van landbou-ekonomie ter oplossing van landbou- en landelike beleidsprobleme te ondersteun en om skakeling tussen landbou-ekonomie op streeks, nasionale en internasionale vlak aan te moedig.

Dr Backeberg sê die prioriteit aktiwiteite van LEVSA sal hoofsaaklik die volgende behels:



Dr Gerhard Backeberg

- Die jaarlikse aanbieding van 'n nasionale konferensie;
- Die jaarlikse aanbieding van die FR Tomlinson-gedenklesing om erkenning te verleen aan 'n persoon vir bydraes gelewer tot die vakgebied van landbou-ekonomie in Suid-Afrika;
- Die reël en ondersteuning van *ad hoc* simposia, lesings of besprekings op nasionale of streeksbasis;
- Die publisering van 'n nuusbrief, 'n vaktidskrif en konferensieverrigtinge;
- Die maak van toekennings ter erkenning van voortrefflike prestasie op die gebied van publikasies.

Vir meer inligting skakel asseblief die sekretaris van LEVSA, mnr Rolf-Joachim Otto by telefoon (012) 319-6160 of faks (012) 323-8435.

TRICON and BAYES PC software programs adapted for running under the UNIX system

J BUYS
G.J. VAN TONDER
J.F. BOTHA

CONVERSION OF THE SOFTWARE PACKAGES TRICON
AND BAYES FROM PERSONAL COMPUTERS TO
MACHINES USING THE UNIX OPERATING SYSTEM

Report to the
WATER RESEARCH COMMISSION
by the
INSTITUTE FOR GROUNDWATER STUDIES
UNIVERSITY OF THE ORANGE FREE STATE

WRC Report No 566/1/95

Copies of the final report entitled
**Conversion of the software
packages TRICON and
BAYES from personal com-
puters to machines using
the UNIX operating system
(WRC Report 566/1/95)** are
available free of charge from
the Water Research
Commission, PO Box 824
Pretoria 0001.
(Overseas price: US\$20.)

The fact that groundwater is largely invisible to the naked eye together with the unique nature of aquifers, make it extremely difficult to manage groundwater resources. One method to overcome these difficulties is to represent groundwater data, such as water levels in observation boreholes, graphically by means of contour maps.

The software programs TRICON and BAYES were originally developed for use on a personal computer for the contouring and interpolation of geohydrological data and formed part of a research project between the Water Research Commission (WRC) and the Institute for Groundwater Studies at the University of the Orange Free State, entitled: A comparative study of two- and three-dimensional groundwater models. The main functions of TRICON and BAYES are:

- To draw accurate and aesthetically acceptable contour maps of a regionalised variable - that is a variable that varies in space;
- To estimate values of a regionalised variable and its associated error, at points where no measurements are available.

Both these programs were developed for use on IBM-compatible personal computers running under the DOS operating system, because of the widespread use of these machines in South Africa. However, towards the end of the project it became clear that the memory limitations under the DOS operating system, limited the application of both programs considerably. A research proposal for converting TRICON and BAYES to machines using the UNIX operating system was therefore put before the WRC. The WRC accepted the proposal and work on the project began in January 1993.

REPORT

A report compiled by the researchers, J Buys, GJ van Tonder and JF Botha, from the Institute for Groundwater Studies at the University of the Orange Free State, describing the work carried out under this project is now available from the WRC.

According to the report the work was undertaken in different phases, namely:

- The conversion of the program TRICON to the SUN workstation environment so that it can run under the UNIX operating system;
- The combination of the BAYES program with the program KRIGING, developed by Professor GJ van Tonder at the Institute for Groundwater Studies, into a software package called TRIPOL that includes three different interpolation methods, i.e the classical distance weighting method, Kriging and Bayesian estimates. A facility for the computation of semi-variograms and the fitting of a theoretical semi-variogram to the semi-variogram values, needed by the Kriging and Bayes methods, were also included.
- The development of user friendly interfaces for the DOS version of TRIPOL and the UNIX and SUN versions of both TRICON and TRIPOL.
- The replacement of the DOS graphic library, PLOT 88, presently used on DOS machines, with a Postscript library.
- The incorporation of TRICON into the groundwater GIS system, presently under development at the Institute for Groundwater Studies.

In conclusion, the user manual for TRICON was adapted for the UNIX version and a user manual for TRIPOL was written from scratch. The user manuals are included in the final report.

Scientific information on South Africa's estuaries documented



River mouth in the warm temperate region at Sedgfield.

A collation of available scientific information on individual southern African estuaries has recently been published in the form of a report and is currently available from the Water Research Commission in Pretoria.

The publication has been prepared to provide researchers, planners and managers with an easily accessible source of scientific information on the various estuarine systems in South Africa. It forms part of a programme for establishing the importance and present status of South African estuaries and has been compiled by AK Whitfield of the Consortium for Estuarine Research and Management.

In addition to providing valuable data sources for individual estuaries, this document also highlights those systems for which little or no information is available. Most of the former Ciskei and Transkei estuaries fall into the latter cat-

egory, and systems within these regions should therefore be targeted as priorities in future information gathering exercises, the report says.

REGIONS

For the purposes of this document all the estuarine systems in the country have been divided into three major biogeographic regions, namely, subtropical from the Kosi estuary in KwaZulu-Natal to the Mbashe estuary in the Eastern Cape, warm temperate from the Mendu estuary in the Eastern Cape to the Silwermyl estuary in False Bay, and cool temperate from the Krom (Wes) estuary on the Cape Peninsula to the Orange River mouth on the Northern Cape coast.

The estuarine classification system used classifies estuaries into permanently open estuaries, temporarily open/closed estuaries, estuarine lake systems, estu-

arine bays and river mouths. Individual estuarine systems may change from one type of estuary to another under the influence of natural events or anthropogenic influences. Human induced changes have resulted in rapid and dramatic alterations to a number of systems, e.g. Richard's Bay has been transformed from an estuarine lake into an estuarine bay through harbour developments. (It should be noted that an estuarine water body must have a water surface area exceeding 1 200 ha to be considered as an estuarine lake or estuarine bay system.)

The condition of each estuary, which is based on the degree to which human activities have changed the functioning or viability of a particular system, is broadly classified as poor, fair, good or excellent. These assessments are based on the opinions of scientists from the different regions as well as use of the literature data base presented in this publication.

Copies of the publication entitled **Available scientific information on individual South African estuarine systems (WRC report 577/1/95)** are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001 (Overseas price: US\$ 25,00.)

Researcher demonstrates the potential of GIS technology in hydrosalinity modelling

The results are now available of a research project in which a geographical information system (GIS) was integrated with the Daily Irrigation and Salinity Analysis (DISA) model thereby determining the application potential of GIS in hydrological modelling.

The work was carried out by B Wolff-Piggott of the Institute for Geographical Analysis at the University of Stellenbosch and funded jointly by the Water Research Commission and the Department of Water Affairs and Forestry. The researcher concludes in his final report to the Commission and the Department that the use of GIS offers a number of significant advantages in the application of the DISA model, including faster spatial data capture, powerful visual tools for error detection and an automated spatial data analysis.

INPUT DATA

Many hydrological models such as the DISA model require input data of a geographical nature. Before the advent of geographical information systems much of this data were laboriously measured and calculated from existing maps. Due to this time consuming and tedious process the full potential of hydrological modelling could often not be realised.

The DISA model is a physically-based hydrological simulation tool for the management of water supply to irrigation schemes and was developed using the extensive research that had been conducted on salinisation in the Breede River valley in the Western Cape.

The DISA model is dependent upon spatial data sets or themes. These themes include irrigation areas, farm boundaries, catchment boundaries, the water distribution network, soils, mean annual precipitation and evaporation data. The themes are used for so-called "catchment discretisation" into model cells. With the DISA model there is little flexibility with regard to trivial changes to the spatial themes that are used to define the model cells. As a result, it has been difficult to simulate the system under varying spatial resolutions. This also means that the model cannot easily be applied to other drainage systems in its original form. However, by developing an interface between a geographical information system (GIS) and the DISA model these inhibiting factors could be overcome.

REPORT STRUCTURE

The final report summarising the research results is structured as follows:

A literature review is presented in Chapter 2 and the results of the review are summarised to identify the principles on which the project was based. The DISA model and the Arc/Info GIS are discussed in Chapter 3 to introduce the systems and to provide insight on aspects of particular importance to the interface development. The DISA model is considered in terms of the modelling approach it embodies, its structuring of the catchment information, the data required to operate the model and the feasibility of data interchange. Similarly, Arc/Info is analysed in terms of its data model, software structure and interfacing capabilities.

The GIS database design is dealt with in Chapter 4. First the data requirements of DISA are considered in the light of data availability and some implications for the database design are drawn. A conceptual design for the interface between DISA and

Arc/Info is proposed and the implementation of this interface is then described. The verification of this interface is discussed in Chapter 5. An internal verification is performed, checking the consistency of the interface by matching the file format produced from Arc/Info against the original file. The GIS-derived data is compared to the original configuration file and model results using both data sets are compared for the external verification. Finally, the achievements of the project are critically assessed in the concluding chapter.

Technical information is presented in a number of appendices to the main text. This includes a detailed description of the GIS database design, an overview of the coding undertaken for the interfacing and a guide to setting up and using the interfaced systems. The guide is intended to enable readers familiar with both UNIX Arc/Info and DISA to apply the interface described in this report in a different study area.

Copies of the report entitled **Demonstrating the potential of GIS technology in hydrosalinity modelling through interfacing the DISA model and a GIS** (WRC Report 588/1/95) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20,00.)

B WOLFF-PIGGOTT

DEMONSTRATING THE POTENTIAL OF GIS TECHNOLOGY IN HYDROSALINITY MODELLING THROUGH INTERFACING THE DISA MODEL AND A GIS

Report to the
WATER RESEARCH COMMISSION
by the
INSTITUTE FOR GEOGRAPHICAL ANALYSIS
UNIVERSITY OF STELLENBOSCH

WRC Report No 588/1/95

Guidelines developed for water quality monitoring strategies in the forestry industry

“Future legislation controlling non-point pollution may affect the forestry industry and their management of catchment water resources” says researcher W Lesch of Forestek, CSIR, in a report to the Water Research Commission. An increasing awareness of the need to protect the quality of South Africa’s water resources, has resulted in a growing awareness of the necessity to control non-point pollution as well. Despite vigilant point source pollution control, the quality of water in South Africa has steadily continued to deteriorate.

The Department of Water Affairs’ new receiving water quality objectives (RWQO) approach which specifies the water quality requirements of receiving waters, requires control of both point and non-point source pollution. Forestry will be required to meet these

water quality requirements with regard to water flowing from afforested catchment areas.

A research project, funded by the Water Research Commission, was undertaken by Forestek, CSIR, to analyse and synthesise inorganic streamwater quality data collected over 16 years in afforested montane catchment areas in South Africa. The aim of this analysis was to develop guidelines which the forestry industry could apply in a cost-effective way to monitor impacts of forestry management practices on water quality. This entailed identifying the most important water quality variables, and also where and how to sample to obtain reliable data. Suspended sediment, $\text{NO}_3\text{—N}$, $\text{PO}_4^{+}\text{—P}$, K^+ and Ca^{2+} were found to be reliable indicator variables of the impacts of forestry management practices.

The project report entitled **The development of guidelines for the design of streamwater quality monitoring strategies in the forestry industry** (WRC Report no 524/1/95) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. (Foreign price: US\$ 20)

Montane headwater catchments receiving more than 800 mm rainfall per annum are regarded as invaluable water resource areas of South Africa, as the major part of the country is classified as arid or semi-arid. The forestry industry is concentrated mainly in the higher rainfall regions, and is therefore a significant role player in water resource management.

According to the report the forestry industry has emphasised water yield in its water resource management, allowing for sufficient flow from planted-up areas. However, the emphasis has now shifted

to include the quality of the water emanating from afforested lands.

Mountain catchment areas with undisturbed indigenous vegetation are generally regarded as sources of pristine quality water. Natural ecological disturbances in these areas, for example the burning of fynbos in the south-western Cape and grasslands in the Natal Kwa-Zulu highlands, do not have any detrimental effects on the quality of the water.

However, recent studies on the effects of clearfelling of forestry plantations on water quality have shown that some vari-

ables are indeed affected by the change of vegetation.

AIMS

The aims of this project were:

- to investigate the importance of specific water quality variables as indicators of the impacts of forestry management practices (through an intensive analysis of the stream water quality data currently available on the Forestek database).
- to determine possible correlations between stream water quality variables which would indicate if some variables can be used as indicators for others.
- to provide guidelines for the forestry

industry, for the most cost-effective methods for water quality monitoring for both short- and long-term goals.

The water quality variables that were included / investigated in this study are: suspended sediment, pH, conductivity, sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), ammonia (NH_4^+), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), phosphate (PO_4^{3-}), bicarbonate (HCO_3^-), TP (total phosphate), KN (Kjeldahl/total nitrogen), silicon (Si) and fluor (F).

The study was carried out in a number of successive steps: first an intensive analysis of the existing data on the data base of Forestek was done. The following step was to use the data to determine sampling frequency and to develop procedures for selecting appropriate sampling sites to obtain reliable data on the impact of forest management practices on water quality. Recommendations in the literature regarding sampling sites were incorporated in this section. Finally, guidelines for practical and cost-effective monitoring of streamwater quality in afforested areas were compiled using the information obtained from this study.

APPROACH

Water quality data from three different mountain catchment areas were analysed for changes that could be attributed to changes in forestry management practices. These consisted of three catchments under plantations in the south-western Cape (Western Cape Province), two indigenous forested catchments in north-eastern Transvaal, and one partly afforested catchment in the eastern Transvaal. The management practices that were considered varied from riparian zone clearings to afforestation of a once indigenous forested catchment with commercial tree species.

One of the Cape catchments was kept as a control. A second catchment underwent a riparian clearing, followed by the total clearfelling of the plantation (and catchment) and subsequent re-afforestation. Just more than half of the third catchment was under plantation, and this was clearfelled over a period and planted with a second-rotation crop. A few years later the whole of the latter catchment accidentally burnt down, and was planted-up again.

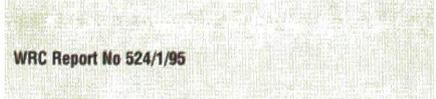
In the north-eastern Transvaal (now part of Mpumalanga) one of the indigenous forested catchments was bulldozed, burnt and a plantation established, while the other was maintained as a control.



THE DEVELOPMENT OF GUIDELINES FOR THE DESIGN OF STREAMWATER QUALITY MONITORING STRATEGIES IN THE FORESTRY INDUSTRY



Report to the WATER RESEARCH COMMISSION by the DIVISION OF FOREST SCIENCE AND TECHNOLOGY, CSIR



WRC Report No 524/1/95

The partly afforested catchment in the eastern Transvaal (now Mpumalanga) underwent several riparian clearings. Before the final burning of the riparian zone, the plantation, which covered 25% of the catchment, was clearfelled.

Samples taken from both high- and low-flow conditions were included in the study. All water quality variables as indicated were analysed.

RESULTS

There were no consistent statistically significant changes in the concentrations of the variables during spates (high flow) as a result of the different forest management practices. Suspended sediment was the only variable that changed as a result of a number of different management practices. The most marked increases in sediment, up to **five-fold**, occurred after a fire burnt a plantation in the south-western Cape. Although the effects were short-lived, the extent of the increases indicated that spate sampling would be needed to monitor such extreme changes in vegetation cover. Grab-sample concentrations of suspended sediment, $\text{NO}_3\text{-N}$, $\text{PO}_4^{3-}\text{-P}$, K^+ and

Ca^{2+} provided good indications of the effects of most forest management practices. Management practices which disturbed the upper soil layers caused sediment concentrations to increase in streamwater. The increased concentrations of $\text{NO}_3\text{-N}$, $\text{PO}_4^{3-}\text{-P}$, K^+ and Ca^{2+} is attributed to water percolating through decaying litter, slash, roots and ash and the consequent leaching of these important plant nutrients. $\text{NO}_3\text{-N}$ and K^+ were also found to be indicators of long-term change, with concentration levels being elevated for a number of years following changes in management practices. Intensive site preparation during the conversion of an indigenous forest to plantation caused the most lasting concentration increases of nitrate and potassium in streamwater.

Correlation analyses involving all the sampled variables in all the catchments showed no consistently significant correlations between variables, therefore the variables cannot be used to predict each other.

The method of stream ordering was used to indicate a sampling hierarchy in greater catchment areas. A control or untreated catchment provided a highly effective way of separating actual changes in water quality in the treated area from changes caused by variation in climate. Monthly grab samples were found adequate for general monitoring while specific sampling of high-flow conditions will be needed to determine the effects of extreme management practices or events on catchment water quality.

REPORT

The report consists of two major sections:

- **Part A** discusses the catchment areas studied and the experimental techniques and management practices applied; results of the statistical analyses of spateflow data and grab-sample data; correlation analyses of the relationship between different water quality variables; as well as sampling site selection and sampling frequency.
- **Part B** provides guidelines to forest managers for designing water quality monitoring systems for afforested catchment areas.

WATER & CROP MODELS STUDIED

The Water Research Commission recently published a report entitled *The influence of different water and nitrogen levels on crop growth, water use and yield, and the validation of crop models*. This report emanated from a multi-disciplinary project initiated by researchers of the Institute for Soil, Climate and Water.

The multi-disciplinary project arose out of a need to gain a better understanding of crop growth and water use. The aims of the study centred around characterising the interactive effects of water and nitrogen on the growth, water use and yield of irrigated spring wheat (*Triticum aestivum* L.).

Field experiments were designed with the improvement of crop simulation models in mind, to answer specific questions where information was lacking. A comprehensive series of field measurements was made over four winter seasons (1990-93), and the information was then used to validate various crop models. In the virtual absence of rainfall during the winters the irrigation levels were closely controlled, and therefore a range of water treatments varying from dryland to well-watered was possible in the wheat experiments, say the researchers.

The report (WRC Report no 307/1/95) by S Walker, TP Fyfield, JPA McDonald and A Thackrah, is available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$25.)

S WALKER
T P FYFIELD
J P A MCDONALD
A THACKRAH

THE INFLUENCE OF DIFFERENT WATER AND NITROGEN LEVELS ON CROP GROWTH, WATER USE AND YIELD, AND THE VALIDATION OF CROP MODELS

Report to the
WATER RESEARCH COMMISSION
by the
INSTITUTE FOR SOIL, CLIMATE AND WATER
AGRICULTURAL RESEARCH COUNCIL

WRC Report No 307/1/95

As the demand on the water resources of South Africa is increasing rapidly due to urbanisation and industrial development, agriculture finds itself increasingly in competition with urban development as well as the mining and industrial sectors for water. It is predicted that irrigation farmers will have to pay a higher price for their water in the future. It is therefore of prime importance that the use of irrigation water in particular should be optimised. Two priorities which the Co-ordinating Committee for Irrigation Research (CCIR) have identified as essential are:

- the development of an irrigation scheduling strategy to minimise the negative effects of plant water stress during water deficit, and
- the development of crop growth simulation models for South African conditions with the emphasis on water-yield relationships.

AIMS

This project had three main focus areas: (i) To characterise the development of the crop canopy and the resistances to

water flow in the soil-plant-atmosphere continuum under different water-nitrogen regimes (in a field experiment),

(ii) To validate, under South African conditions, selected crop models used in irrigation planning and management, and to make recommendations for improvements.

(iii) To test the reliability of the BEWAB irrigation scheduling program under the different water-nitrogen regimes, particularly in connection with the water use, water use efficiency and yield predictions.

FIELD EXPERIMENTS

The characterisation of crop canopy development was undertaken in great detail in all four wheat seasons by means of growth (e.g. leaf area and biomass) and physiological (e.g. photosynthesis) measurements. A detailed study of the often neglected crop root system was also made, with the help of a minirhizotron video camera system. Plant water relations were monitored by means of leaf water potential measurements, and the rate of sap flow through a single stem was successfully measured after adapting and calibrating the heat pulse method.

The CERES, PUTU and SHOOTGRO wheat crop growth models, selected as typical of those in current use, were calibrated and validated under South African conditions using the comprehensive dataset generated in the field experiments. The ability of the models to accurately simulate various aspects of wheat production was tested under different levels of applied water and nitrogen. Certain inadequacies were highlighted which could enable model developers to make the necessary refinements.

The BEWAB irrigation program was used to schedule the irrigation throughout the four-year project, and although it was developed in a cooler region it proved to be quite reliable in a warm irrigation area such as Roodeplaas, when tested



The CERES, PUTU and SHOOTGRO wheat crop growth models, were calibrated and validated under South African conditions using the comprehensive dataset.

against measured yield and water use data. However, certain modifications could now be made by the developers of BEWAB, based on the information gained in this project, which would broaden its application base.

SPECIALISED TECHNIQUES

A major achievement of this project was that several specialised scientific techniques were adapted and brought to an operational level for wheat crop measurements:

Firstly, the heat pulse system, which had previously been used only on plants with robust stems such as soybeans, was adapted for use with thin-stemmed wheat tillers. The technique was then calibrated and used to make continuous measurements of single stem transpiration under field conditions. The success of this development will allow the heat pulse system to be used to study the transpiration of a wide range of plants, including grasses.

Secondly, a video camera was used to monitor root growth and development, non-destructively, by means of minirhizotron tubes installed in the soil under

the wheat crop. This technique is new in South Africa and was evaluated in comparison with the destructive coring method. It allows a much more detailed study to be made of the root system than was previously possible, and is particularly suited to monitoring root-turnover over extended periods.

Thirdly, a detailed field evaluation was undertaken of a system for measuring single leaf photosynthesis. Guidelines were developed for the precautions necessary when using a leaf chamber in order to obtain accurate measurements on a routine basis. The technique was then used to establish the relationship between photosynthesis, leaf age and leaf nitrogen content for wheat leaves throughout the growing season.

GUIDELINES

Another valuable contribution arising from this study was the guidelines developed for farmers regarding the amount of irrigation water to apply and the optimal nitrogen application recommended for a specific target wheat yield in the warm irrigation region. For example, for spring wheat cultivars grown in a deep soil with a high clay content, in order to obtain a

grain yield of 6-7 t/ha, a nitrogen fertilizer application rate of 135 kg N/ha is recommended.

According to the report, the Roodeplaat study indicated that a seasonal water use of approximately 550 mm would be required for this target yield if irrigation was applied weekly, but only 440 mm if it was applied once every two weeks. The efficiency of irrigation water could thus be improved if these guidelines are followed, and a higher yield produced per unit of irrigation water applied.

DATA SET

The main legacy of this project is the large and comprehensive dataset that was generated, which characterises the effects of different water and nitrogen application levels on the growth, water use and yield of a spring wheat crop.

The researchers say that this information is of great scientific value as the processes involved are now better understood, and it is most valuable in the calibration, validation and refinement of crop growth models. The dataset is now available to any scientist who is able to make further use of it.

Survey evaluates South African shack dwellers' access to water and waste services

Recent research done by the Palmer Development Group for the Water Research Commission indicates that some earlier assumptions about levels of access to water and sanitation - taps and toilets - for backyard shack-dwellers in South Africa's black townships have been too pessimistic. The researchers found that only four per cent of backyard shack-dwellers did not have access to water on site.

'Backyard shacks' are informal dwelling structures erected on legally established and serviced residential stands which also have a formal house on the stand. In mid-1990 there were an estimated one and a quarter million formal housing units in black townships in South Africa with an associated 350 000 backyard shacks.

Despite increasing numbers, backyard shacks have attracted relatively little comment, systematic research and official response. This lack of information has meant that studies on access to water and sanitation or stormwater run-off quality had to rely on crude estimates regarding on-site conditions in the denser, older townships.

The researchers did a survey of backyard shacks and on-site conditions in six different townships. The results are summarised in the final report entitled "Water and sanitation in urban areas: survey of on-site conditions". Copies of this report (WRC Report 561/1/94) are available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. (Foreign order price: US\$ 20.)

The aim of the research project was to evaluate conditions affecting water and waste services on sites where backyard shacks have been constructed. More specifically, the project aimed to determine the following:

- to what extent do people in the informal dwellings get access to water on site. How free is their use of it and how are they charged by the main household?
- to what extent do people in dwellings which do not have a toilet get access to

the toilet in dwellings which have one. What do people do as an alternative?

- the situation with regard to solid waste storage and disposal on sites in order to gather information which may be used to assess the implication this may have on stormwater run-off quality.

Approach

A case study approach was followed and 315 sites were surveyed in six different townships across South Africa in

the period December 1992 to May 1993. This broad geographic spread was important as conditions in townships and regions differ widely. The townships surveyed were: Nyanga (Cape Town), Alexandra (Johannesburg), Mamelodi (Pretoria), Clermont (Durban), Kwa-Thema (Springs) and Thabong (Welkom). A total of 4 882 people living on the 315 sites were interviewed.

Sites to be interviewed were selected from the parts of formal townships where 'backyard living' was most prevalent.

Therefore the survey is not representative of these townships as a whole, since backyard shacks are generally confined to specific parts of a township, typically the older, more centrally-located sections.

Results

The survey findings in relation to access to services can be summarised as follows:

□ Access to water

Almost all of the people in the shack-dwellings had access to water on site. On sites where there were constraints or arguments on the use of the taps, the main contributing factors were: the number of taps, the number of people per tap and the location of the tap on the site. No practice of point sales of water to tenants was reported, and water price charges were generally in accordance with the official water tariff in the township.

□ Access to sanitation

Most of the people in the shack-dwellings had access to on-site toilet(s). On sites where there were problems over toilet use this was mainly related to: general maintenance, the number of toilets, and the location of the toilet on the site. As an alternative the people use their workplace, the neighbour's toilet, the garden or the veld. No practice of per visit charges for toilet use were reported.

□ Solid waste services

Refuse storage and removal was problematic on most of the sites. Linkages between such problems and poor stormwater quality are suspected in four of the six townships. The major contributing factors were a shortage of refuse bins and bags for storing waste until collection, and the very poor refuse removal services operating in five of the six townships surveyed.

Conclusions

The researchers say a number of observations can be made in relation to the survey results:

□ 'Backyard living' allows access to formal services to a large urban population who would otherwise not have access to such services. As such, it can be assumed that the majority of backyard shack-dwellers enjoy significantly better levels of access to services than the populations of informal and squatter settlements with no dedicated or only rudimentary services.



WATER AND SANITATION IN URBAN AREAS: SURVEY OF ON-SITE CONDITIONS



Report to the
WATER RESEARCH COMMISSION
by the
PALMER DEVELOPMENT GROUP

WRC Report No 561/1/94

□ 'Backyard living' can be an important source of income to the main household (who may not actually own the property). It assists in paying for site rentals or bond repayments and shares the cost of service connections and supplies to the site. The shackdwellers are generally able to save on transport costs by living closer to places of employment than would otherwise be possible. For these and other reasons 'backyard living' is very unlikely to disappear. In certain areas it may become less intense with time as serviced plots and housing become available nearby.

□ The overcrowding of sites is creating problems for particularly waste services in the densely settled parts of townships. However, such problems mostly relate to an already poor maintenance and operation situation shortage in most developing urban areas. 'Backyard living' is making an already bad situation worse, but it is not the major cause of such operating problems.

From the information obtained on each of the services, the following emerge as the major requirements for improving services to those in 'backyard living' conditions:

□ An improvement in the water supply situation of shack-dwellers who are tenants of the main households requires a sufficient number of taps in relation to the site population located outside the house.

□ An improvement in the sanitation situation of shack-dwellers who are tenants of the main household requires an outside toilet which is well-maintained and operating.

□ An improvement in the solid waste service to 'backyard shack' dwellers requires provision of solid containers for refuse storage inside the yard and an easily understood, reliable removal or disposal service which operates at twice weekly intervals or some other regular arrangement.

Design and planning

The survey has shown that planners, urban managers and housing policy-makers need to obtain a better understanding of the dynamics and patterns of 'backyard living'. The and impact of this important form of spontaneous informal housing will have to be carefully considered in:

- the design of houses and sites;
- in the design of reticulation and bulk infrastructure;
- setting up solid waste removal systems,
- in structuring housing finance and subsidies;
- in setting services tariffs and site rentals; and
- controlling land-use in developing urban areas.

According to the report backyard living has a number of design implications. In addition to outside access to taps and toilets, the provision of robust containers for refuse storage should be considered as basic service requirements. Solid waste is possibly emerging as the major problem area for densely occupied environments.

Potential impacts of rainfall stimulation modelled

Research into glaciogenic seeding of convective storms in the Nelspruit-Carolina region was funded by the Water Research Commission (WRC) in the 1980s. A similar research project in the Bethlehem region was funded by the Weather Bureau.

Promising findings in these projects showed potentially positive effects of cloud seeding on rainfall, consequently the WRC requested researchers to identify and prioritise further research into rainfall stimulation and its potential impacts. The derivation of modified rainfall scenarios to assess incremental seeding effects was proposed as a first step.

Researchers quantified the positive average seeding effects on storm rainfall based on the findings of the Nelspruit project. Subsequently these average effects were used in software which was developed to generate "seeded" daily rainfall sequences

based on the available set of long-term rainfall records. The availability of these augmented "seeded" daily spatial rainfall sequences, made it possible to model and study the potential impacts in various "end user" fields such as water resources and timber yield on computer.

Researchers GJ Howard and AHM Gørgens undertook the modelling of potential impacts of rainfall stimulation in the 'end user' fields of water resources and forestry in the rainfall stimulation target zone located in the Eastern Transvaal. Their findings are reported in the WRC report entitled **The potential impacts of rainfall stimulation on water resources and forestry in the Nelspruit-Bethlehem target zone** (WRC report 439/1/94). Copies of the report are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas order price: US\$ 25,00.)

The aims of this specific research project was:

- ❑ to mathematically model the potential augmentation of runoff from selected gauged pilot catchments in the rainfall stimulation target zone;
- ❑ to mathematically model the potential increase in timber production from selected pilot catchments in the rainfall stimulation target zone;
- ❑ to quantify the statistical dispersion of the potential impacts in the pilot catchments for both runoff and timber yield by utilising a large number of alternative rainfall time series which have been hypothetically augmented;
- ❑ to transfer results and findings from the pilot catchments to the entire target zone.

METHODOLOGY

In this project these impacts were assessed by means of the verified *ACRU* rainfall-runoff model for both runoff and

timber yield using the large number of pairs of stochastically-generated and augmented daily rainfall sequences. Initially, the *ACRU* model was verified on the thirteen selected catchments, by comparing simulated with observed monthly streamflow sequences.

These pilot catchments were located in all the major river basins of the region, namely the Vaal, Usutu and Crocodile River basins. This task required the collection of historical and current day land-use data, physical data such as soil type and climatic data.

The verified *ACRU* configuration was then adapted to reflect present day development and used to generate a large number (100) of stochastic and augmented runoff and timber yield sequences, each of 30 years duration. A reservoir yield analysis, using the concept of firm yield (no failure) and based on a reservoir full supply capacity equivalent to one MAR (mean annual runoff), was also included to ascertain the effects on water resources in terms of water resources yield.

A probabilistic exceedance technique (box-whisker plots) was used to compare the statistical dispersion of the stochastic and augmented sequences.

RESULTS

Various aspects of the *ACRU* model output were analysed to quantify and explain the impacts of rainfall stimulation on water resources and timber yield. Firstly, the statistical dispersion of the stochastic and augmented sequences using *ACRU* runoff, reservoir yield and timber yield output were compared for each catchment. **Table 1** summarises these results using the median of the stochastic and augmented sequences.

MEDIAN INCREASES

Results show that the average median increases in water resources (MAR and reservoir yield) and timber yield (on a 10 year rotation) in all the selected pilot catchments are 32 per cent for runoff and 27 per cent for reservoir yield respectively, and 22 per cent for timber yield. Differences in the median percentage increases of catchment runoff, reservoir yield and, to a lesser extent, timber yield are highly variable. Results show the lowest and highest median increases in catchment runoff are 20 per cent in catchment XIH019 and 48 per cent in catchment W5H025 respectively. These increases range from 14 per cent

(C1H006) to 42 per cent (W5H008) for reservoir yield, and 16 per cent (W5H024) to 30 per cent (XI H020) for timber yield.

CONCLUSIONS

□ Mean annual runoff (MAR) and Reservoir Yield: The average median increase in MAR and reservoir yield is 32 and 27 per cent respectively. Catchment increases in reservoir yield range from 14 per cent to 42 per cent.

□ Timber Yield : The average median increase in timber yield is 22 per cent. Catchment increases range from 16 to 30 per cent.

□ Statistical Dispersion: There is a significant variability in water resources. Increases in reservoir yield range from 0 to 68 per cent using the 5 percentile and 95 percentile. The variability in timber is less significant and ranges from 14 to 34 per cent using the 5 percentile and 95 percentile.

□ Spatial Extrapolation: Extrapolation of pilot catchment results on a regional basis indicated the Usutu River basin as having the highest potential median increase in both reservoir yield and timber yield (at 33 and 25 per cent respectively).

Table 1 : Median MAR. Reservoir yield and timber (*Eucalyptus*) yield of the Stochastic (S) and Augmented (A) sequences and the percentage increase (for present day land-use).

CATCHMENT NUMBER	MAR (m3 x 10 /a)			RESERVOIR YIELD (m6 x 10 /a)			TIMBER YIELD (m3/ha/rotation)		
	S	A	%	S	A	%	S	A	%
B1H006	3,4	4,6	35	2,4	3,1	30	160	190	22
C1H006	48,0	60,0	25	28,0	32,0	14	-	-	-
X1H016	52,0	65,0	25	47,0	58,0	23	320	380	22
X1H019	30,0	30,0	20	28,5	33,8	19	270	320	19
X1H020	3,8	5,3	39	2,5	3,4	36	350	460	30
X1H021	46,0	57,0	24	38,0	46,0	21	430	500	17
X2H008	10,0	13,5	35	8,6	11,4	31	390	465	19
X2H030	8,5	10,4	22	8,1	9,4	16	275	325	18
X2H031	23,0	31,0	35	22,0	28,0	27	280	345	23
W5H004	27,0	35,0	30	21,0	27,5	31	300	370	23
W5H008	6,8	9,9	46	5,0	7,1	42	325	385	29
W5H024	165,0	210,0	27	105,0	122,0	16	430	500	16
W5H025	25,0	37,0	48	17,0	23,8	40	340	430	26
Average	-	-	32	-	-	27,0	-	-	22

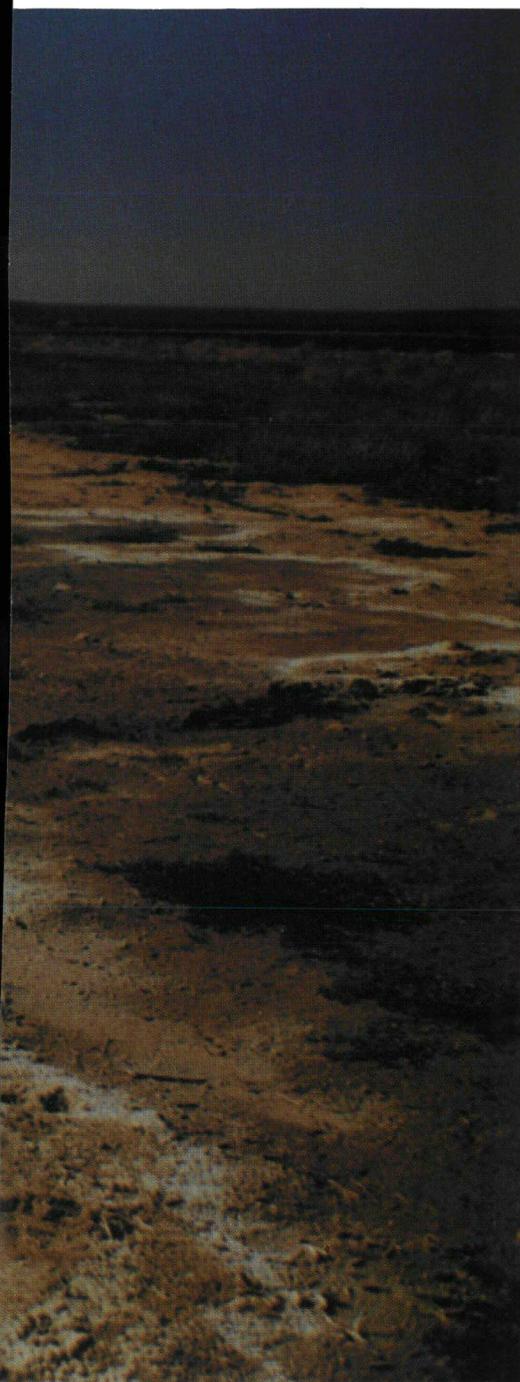


Researcher evaluates two soil salinity mapping techniques

Soil salinity is a serious problem in many of South Africa's irrigation schemes.

The Water Research Commission (WRC) has released the results of a study evaluating two techniques for soil salinity mapping. The main aims of the study were to investigate the four-electrode and electromagnetic induction techniques for soil salinity measurement in South Africa. It was intended that the results obtained with the study would relieve anyone who has to carry out a great deal of developmental work. In particular it was felt that the applicability of the calibration curves and the interpretation of instrument readings needed to be checked locally, and modified where necessary.

A final report summarising the research results is now available. It is entitled "**An evaluation of the four-electrode and electromagnetic induction techniques of soil salinity measurement**" (WRC Report 269/1/94) and copies can be ordered from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price applies.)



es of soil salinity measurement. The
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US\$ 25).

Most of the irrigation schemes in South Africa are affected to some degree by soil salinity. This accumulation of salts in soil is often associated with waterlogging that occurs primarily in the poorly drained regions of the landscape. Soil salinity is also increased by irrigation with saline water.

There is a need, therefore to monitor trends in soil salinity levels on irrigation schemes. However, while conventional methods of measuring salinity, that is, sampling and laboratory analysis, are successful, they are extremely slow and expensive. Methods are clearly required that will facilitate rapid but affordable characterisation of soil salinity.

Over the past 10 to 15 years important advances have been made in the United States and Canada towards meeting this requirement, in that the four-electrode and electromagnetic induction techniques have been developed. Both instruments are able to make rapid measurements of the electrical conductivity of the bulk soil.

To evaluate these induction techniques of soil salinity measurement under South African conditions the Water Research Commission sponsored a research project at the University of Natal's Department of Agronomy. The main emphasis of this study, carried out by MA Johnston, was on the calibration of the four-electrode and electromagnetic induction sensors in terms of conventional parameters of soil salinity. It was intended that the results obtained would relieve anyone acquiring these instruments of having to carry out a great deal of developmental work.

According to the final report summarising the research results the four-electrode system requires the insertion of electrodes into the soil, while the electromagnetic induction sensor is positioned above-ground. Instrument response is primarily influenced by the soil water content and the concentration of dissolved salts in the soil water. While field capacity is regarded as being ideal for taking instrument measurements, the water content varies for soils of different texture. This presents a difficulty for the interpretation of readings because the standard parameter of soil salinity char-

acterisation, the electrical conductivity of the saturation extract, relates to the salt concentration in the soil water at field capacity. Further, it has been shown that charged clay colloid surfaces, with their associated concentration of counter ions, give rise to enhanced current flow. Meaningful interpretation of instrument readings demands, therefore, that the instruments be calibrated for different soil conditions.

Relationships between instrument readings and electrical conductivity of saturation extract have been established overseas, but there was uncertainty as to their applicability under South African conditions. This Water Research Commission project aimed to address this issue. It also investigated the influence of certain additional soil factors on calibration relationships.

MA JOHNSTON

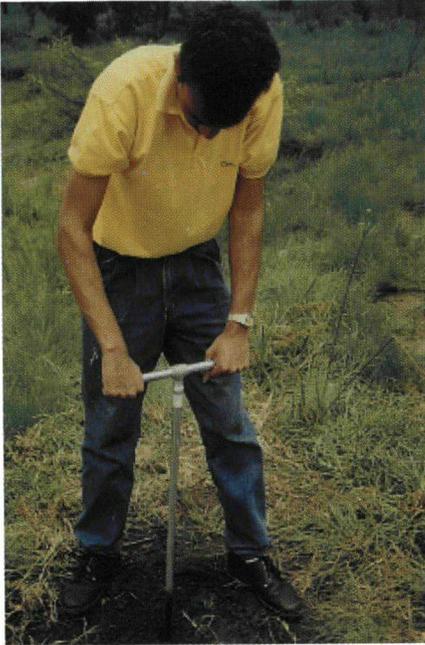
AN EVALUATION OF THE FOUR-ELECTRODE AND ELECTROMAGNETIC INDUCTION TECHNIQUES OF SOIL SALINITY MEASUREMENT

Report to the
WATER RESEARCH COMMISSION
by the
DEPARTMENT OF AGRONOMY
UNIVERSITY OF NATAL

WRC Report No 269/1/94

The report says it should be pointed out that the soil properties that influence the instrument response are fundamentally similar for the two instruments. However, whereas the four-electrode system lends itself to detailed studies under controlled conditions, the electromagnetic induction system does not. It was appropriate, therefore, to study the two instruments in a single project so that the findings for the four-electrode system could complement those for the electromagnetic induction sensor.

First ...



In taking measurements with the four-electrode probe a small hole must first be augered.

Then...



The probe is then forced into the soil and the electrical conductivity measured on the meter.

RESULTS

The four-electrode system

The four-electrode calibration exercises were conducted in the field at 30 sites, and usually at two depths.

Good correlations were generally obtained between the measured electrical conductivity of bulk soil at field capacity and electrical conductivity of saturation extract values. The slope of the linear regression function was found to relate most strongly to the volumetric water content of the soil at the sites studied, but strong correlations were also obtained for silt and clay content, mass water content (at field capacity), water content of the saturated paste and clay content. For the regression intercept, the cation exchange capacity of the soil gave the strongest relationship. The other parameters, however, produced weak relationships.

□ Laboratory studies showed that the soil water content affected the calibration relationships dramatically. A scheme in tabular form was established for the data obtained, which allowed the determination of the regression slope for a wide range in soil water content and silt and clay content.

□ The compensating influence of evaporative drying on electrical conductivity of bulk soil in terms of increased electrolyte concentration of the soil solution was found to exist but only to a minor extent. This study was conducted in the laboratory using the four-electrode pressure cells.

□ With regard to soil structural effects on the calibration, a comparison between results obtained in the field (on undisturbed soil) and laboratory (soil ground and re-packed) showed good agreement,

suggested that the macrostructure did not have a great impact on the calibration. However, on the other hand, where microstructure was degraded by high sodium and pH conditions, a reduction in the regression slope was identified.

□ Calibration characteristics were not influenced by a change in the cation status where soil physical characteristics were not degraded (that is for sodium adsorption ratio levels of the soil water between 0 and 8).

□ The validity of calculating the electrical conductivity of bulk soil values for successive depth intervals from measurements made with the four-electrode surface array at increasing electrode spacing was investigated. Using data from 29 sites representing a variety of soil types and salinity distribution patterns, the calculated electrical conductivity values for successive 0.3 m depth increments down to 1.2 m was found to agree reasonably well with those measured with the probe attachment. The values tended to be underestimated in the 0 to 0.3 m depth interval by about 14 per cent, and overestimated at the 0.9 to 1.2 m depth by about 35 per cent. The calculated values for the intermediate two depth intervals were shown to be very reliable. The general agreement was certainly adequate for purposes of salinity diagnosis.

Electromagnetic induction sensor studies

To evaluate the published calibration models for the EM-38

sensor, studies were made at 110 sites located in saline areas on various irrigation schemes throughout South Africa. At each site instrument readings were taken with the EM-38 and the four-electrode probe and the soil sampled for analysis.

Salinisation of high-value irrigation land is very undesirable in view of the adverse effect on crop production

□ The evaluation showed that the calibration models that predict electrical conductivity of the bulk soil were more reliable than those that predict electrical conductivity of the saturation extract. There was a strong tendency to underestimate the measured values of electrical conductivity of the saturation extract. When the predicted electrical conductivity of bulk soil was translated to the more meaningful parameter of electrical conductivity of saturation extract, the error increased greatly.

□ It was found that readings on the EM-38 sensor required temperature correction to 25°C and that the temperature measured at a depth of 0.45 m provided a value representative of the profile.

□ Because of the rather disappointing performance of the overseas models, calibration equations were derived from this data set for the prediction of the electrical conductivity of the saturation extract for the soil profile.

Field testing

□ A final evaluation of calibration equations was done using a new data set acquired at 30 sites. The performance of the locally produced calibration models showed no meaningful improvement over the overseas models and again tended to underestimate the electrical conductivity of the saturation extract. The researcher concluded that calibration models were limited in their reliability due to variations in the distribution pattern with depth of soil water content and salinity level. Calibration relationships should ideally be established for the soil conditions pertaining to each survey.

□ In addition, a salinity survey was conducted on a 7 ha area to compare these electrical techniques with conventional methods. The EM-38 sensor was found to be superior to the four-electrode array system for salinity mapping. It was quicker and more convenient to use. Poor soil/electrode contact on recently tilled soil in a portion of the field studied furthermore prevented reliable readings being taken with the four-electrode array system. The cost for each of the electrical techniques was less than R100 per ha and was far lower than that for the conventional sampling and analysis (approximately R1 100 per ha).

The four-electrode probe



The four-electrode probe and electrical conductivity meter for measuring soil EC at selected depths down the profile.

The EM-38 sensor

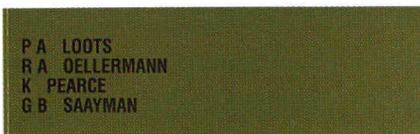


The EM-38 electromagnetic induction sensor that can make rapid measurements of soil salinity without close contact with the soil. All other sensors that measure electrical conductivity require intimate contact between soil and the sensor.

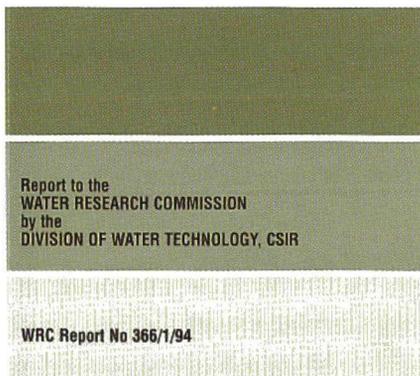
Phosphate crystallization in biological wastewater treatment systems explored

The results of a pilot-scale study on the crystallization of phosphate in biological wastewater treatment systems have been released by the Water Research Commission in Pretoria.

The study, carried out by PA Loots, RA Oellermann and K Pearce from the Division of Water Technology at the CSIR in collaboration with GB Saayman of the City Council of Pretoria, aimed at the establishment of a suitable reactor configuration as well as the determination of the critical design and operational aspects on which the successful commissioning and maintenance of a phosphate crystallizer will depend. However, the researchers say phosphate crystallization is a relatively recent technological development and a number of unforeseen obstacles were experienced in the design and operation of the pilot plant. The original objectives set for the investigation were therefore modified during the course of the investigation by the Steering Committee and it was decided to concentrate the research efforts on the pilot-scale crystallization and no full-



PILOT STUDIES ON PHOSPHATE CRYSTALLIZATION IN BIOLOGICAL WASTEWATER TREATMENT SYSTEMS



scale evaluation was conducted. Chemical modelling and laboratory investigations were resorted to in order to be more effective in the studies at pilot-scale. The researchers say in the final report summarising the research results that the limitations of the laboratory system at low flow rates resulted in the accrual of limited data on some objectives, particularly those subsidiary to correct design and proper operation. However, the data and knowledge gained in solving the problems funda-

mental to process performance was adequate to provide a crystallizer design and consider operational aspects for the successful implementation of the crystallizer technology, integrated with municipal treatment works.

Chemical Modelling

The objective of this component of the study was to apply a dynamic chemical model, namely the Joint Expert Speciation System (JESS), to the problem of removal of phosphates by precipitation with calcium. It has been suggested, on empirical evidence, that the presence of carbonate at elevated concentration (5 millimolar) leads to inefficient crystallization of phosphates and concomitant crystallization of calcium carbonate.

The researchers say the simulations suggest that the crystallization process is governed by the relative rates of precipitation of the solids present. The most stable phosphate-containing solid possible in the system, hydroxyapatite (HAP) forms slowly and less stable solids, octacalcium phosphate (OCP) and tricalcium phosphate (TCP), either also form simultaneously, or form instead of any hydroxyapatite. Under these conditions, if calcium is scavenged by precipitation of calcium carbonate, removal of phosphate is predicted to be low. Therefore, the researchers say, to optimise phosphate removal, it is desirable to remove car-

bonate. The method suggested is a lowering of the pH by addition of sulphuric acid, removal of the carbonate as carbon dioxide by venting and re-adjustment of the pH with lime slurry. This process was simulated by JESS and it was found that the sulphate added as sulphuric acid to effect the pH reduction was low enough in concentration so as not to interfere with subsequent crystallization of calcium phosphate species. The model also showed that the proposed method of carbonate removal was a viable process.

Laboratory evaluation

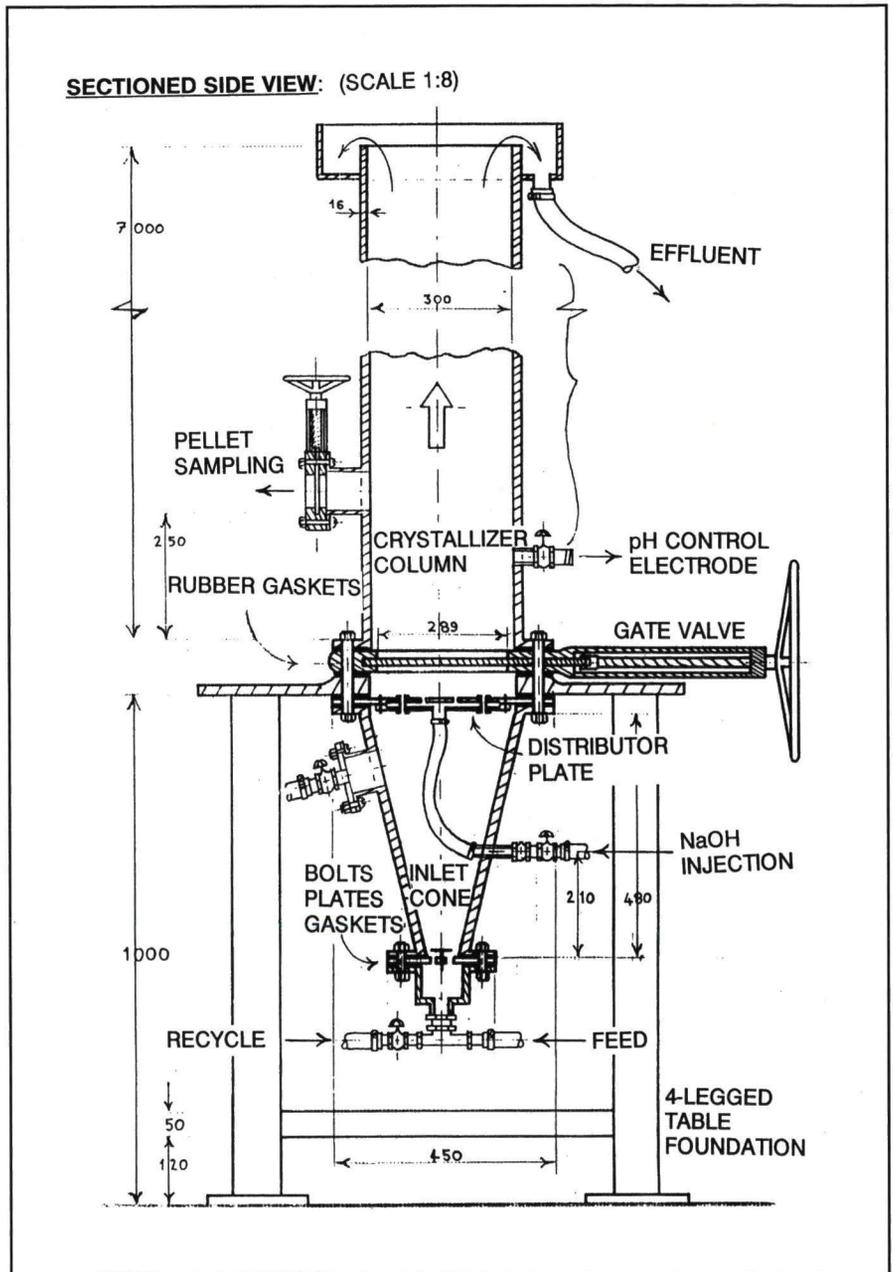
The recycle ratio is an important variable to consider for establishing crystallization efficiency. At constant flow an increase in the recycle ratio results in an increase in the hydraulic retention time. The influent o-phosphate concentration is reduced with a resultant positive influence on the crystallization effectivity. At low recycle ratios floc carry-over increases, whereas at high recycle ratios calcium carbonate precipitation will occur preferentially, thus increasing the concentration of o-phosphate in the outflow.

Effective venting of the influent at low pH reduces the concentration of the interfering carbonate, hence phosphate is preferentially removed from the effluent at all pH values.

As expected, after carbonate removal the concentration of the o-phosphate in the outflow continued to decrease with increasing pH. This effect is not as noticeable at high recycle ratios where the reactor configuration is closer to a completely mixed, rather than a plug flow system. Degassing should therefore have a favourable effect when all other critical performance requirements have been met.

Pilot-scale studies

The researchers say it was difficult to control and maintain optimum process conditions in the pilot plant and the variability of the results did not permit any conclusions on steady-state conditions. However, the results enabled a comparison of the different combinations of interacting parameters important to effective crystallization.



The fluidised bed crystallizer inlet system.

- ❑ Fluctuations in the o-phosphate concentration of the feed to the pilot plant had a significant effect on the crystallization performance.
- ❑ Stringent pH control is the most important operational parameter and is critical for efficient crystallization and reliable performance.
- ❑ Degassing seems to increase the rate of o-phosphate crystallization but also increases the carry-over of o-phosphate flocs.

Under the prevailing conditions, considerable carry-over of o-phosphate flocs was observed and sufficient crystallization could not be achieved. Recycling is needed to stabilise the process, but the return of flocs should be kept to a minimum to reduce any adverse effect on the crystallization performance.

This indicates the need for filtration of the flocs from the effluent discharge before recycling, to effect optimum crystallization and to ensure an effluent with a low o-phosphate concentration.

Economics of crystallization

The maintenance of carbonate levels below two millimolar, to ensure effective phosphate removal, affects the economics of the crystallization technology. When degassing is required the treatment costs, based on the use of sodium hydroxide, amounts to approximately R2.11/m³. This can be reduced to approximately R1.02/m³ if degassing is not essential. The cost of chemicals for degassing thus contributes substantially to the treatment costs. However, only a portion of the total anaerobic effluent flow needs to be treated to reduce the phosphate load on the biological phosphate removal system. If only 10 per cent of the total effluent flow needs to be treated in a crystallizer the foregoing costs, expressed in terms of total effluent flow, reduces to 21 cents/m³ and 10 cents/m³ respectively.

At the prevailing rates, the cost of using lime is only 27 per cent of that of sodium hydroxide. However, the lower solubility of calcium hydroxide would require an additional mixing tank, which partially offsets the savings by using lime. When calcium hydroxide is used instead of sodium hydroxide the direct operating cost is reduced by 26 per cent.

Technology implementation

In this study the researchers have not only demonstrated the feasibility of phos-

phate crystallization but also determined the major design criteria. They say that to implement the technology successfully, requires the following:

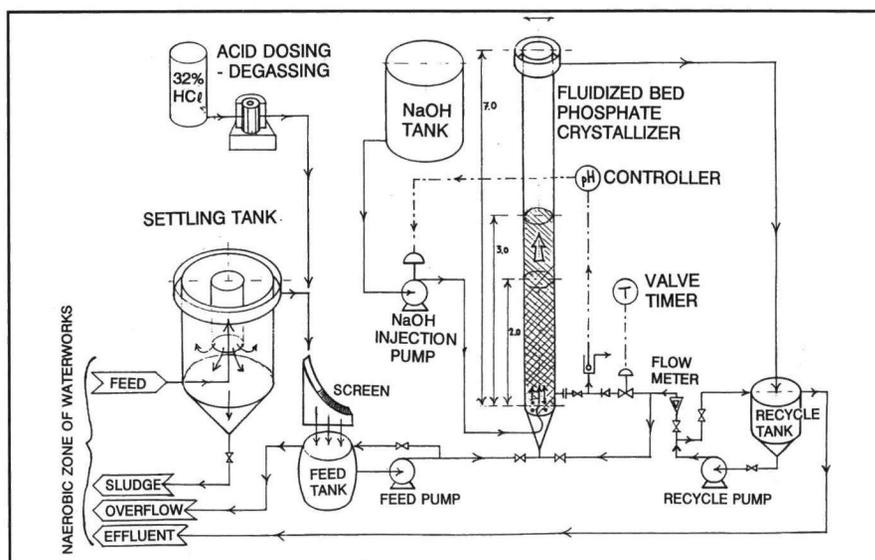
- ❑ Proper crystallizer design, specifically the inlet system is extremely important and is discussed in detail in the report.
- ❑ Suitable quartz sand should be used as crystallization seed material in the fluidized bed.
- ❑ The first step in commissioning should be to establish or maintain a stable and adequately fluidized bed at a linear upflow velocity between 40 m/h to 80 m/h.

❑ Effective CO₂ degassing of water with a high alkalinity is required to reduce the total carbonate content below two millimolar in order to produce crystals resistant to abrasion and to minimise carry-over of o-phosphate flocs.

❑ Concentrated sulphuric acid (98 per cent) can be used for achieving the required degassing pH of 4,8 to 5,0 and one per cent sodium hydroxide or two per cent milk of lime to maintain the crystallization pH between 9,8 to 10,5. Lime can be used where calcium supplementation is required, even though its lower solubility implies additional mixing equipment.

❑ A suitable automated control system for stringent crystallization pH control is an absolute necessity for effective process performance. In this regard special attention must be given to the inhibiting effect of crystallization on an in situ pH measuring electrode.

❑ A slow steady start-up period of three to four weeks is recommended to establish stable operational conditions for a full-scale crystallizer.



Flow diagram of the fluidised bed phosphate crystallizer pilot plant.

❑ A recycle ratio of less than 7 should be used for effective performance of a full-scale crystallizer with a minimum of 1, depending on the economics of the treatment.

❑ Filtration of carry-over flocs from the crystallizer effluent is necessary to obtain a very low o-phosphate concentration (< 1 mg P/l) particularly when recycling of the effluent to the crystallizer inlet is applied.

❑ The mass ratio of Ca:P in the crystallizer influent should be as close as possible to the 2:1 stoichiometric requirement.

❑ The economics of the technology needs careful consideration and is determined by the specific application needs.

Copies of the final report entitled **Pilot studies on phosphate crystallization in biological wastewater treatment systems (WRC report 366/1/94)** are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20,00.)

THE FIFTH SCIENTIFIC ASSEMBLY OF THE INTERNATIONAL ASSOCIATION OF HYDROLOGICAL SCIENCES

23 April - 3 May 1997

R A B A T M O R O C C O

As a member of the Scientific Programme Committee for the 1997 IAHS Scientific Assembly in Morocco, I have been asked to circulate information to you. More details will follow and I already have considerably more details than given below, particularly on the purpose and objectives of the various symposia and workshops, should you be interested (email: schulze@aqua.cwr.ac.za; Tel: 0331-260-5489; Fax: 0331-260-5818).

Roland Schulze

CALL FOR PAPERS

SYMPOSIA: Participants who wish to present a paper or a poster at one of the symposia should send an extended abstract (300-400 words) in either English or French before 15 March 1996.

WORKSHOPS: Participants who wish to present a paper or poster at one of the workshops should send an extended abstract (300-400 words) in either English or French before 31 July 1996.

DEMONSTRATION OF SOFTWARE: Facilities will be made available for software demonstration.

All abstracts should be sent directly to the Convenor of the Symposium or Workshop of choice.

SYMPOSIA

S1 SUSTAINABILITY OF WATER RESOURCES UNDER INCREASING UNCERTAINTY

Convenor: Dr Dan Rosbjerg, ISVA, Technical University of Denmark, Bldg. 115 Lyngby, DK-2800 Denmark.

Email: dan@isva.dtu.dk;

Fax: +45 45 932860;

Tel: +45 45 251449

S1.1 Prediction and management of floods and droughts including drought management planning.

S1.2 Environmental impacts of water resource development, water use and land use change.

S1.3 Advances in hydrological/ecological modelling and environmental risk assessment.

S 1.4 Assessment of the balance between environmental demands and water resources.

S2 HARD ROCK HYDROSYSTEMS

Convenor: M Thierry Pointet, BRGM France, BP 6009, 45060 Orleans Cedex, France
Fax: +33 38 643990; Tel: +33 38 643609

S2.1 Hydrogeochemistry of fissured rock systems.

S2.2 Use of tracers for characterization of fractured rock systems

S2.3 Hydraulic conductivity, scale effects and modelling of fractured rock systems.

S2.4 Artificially created conditions for enhanced groundwater development and management.

S3 REMOTE SENSING AND GIS FOR DESIGN AND OPERATION OF WATER RESOURCES SYSTEMS

Convenor: Dr Michael Baumgartner, Geographisches Institute, Universitat Bern, Hellerst. 12, 3012 Bern, Switzerland. email: baumgartner@giub.unibe.ch; Fax: +41 31658511; Tel: +41 31658859.

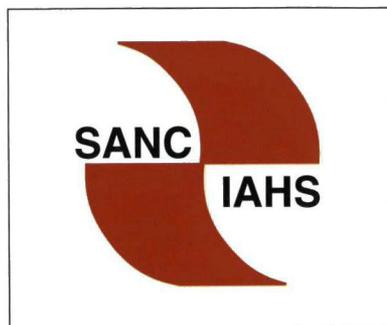
S4 FRESHWATER CONTAMINATION

Convenor: Dr Bruce Webb, Department of Geography, University of Exeter,

Exeter EX4 4RJ, UK.
B.W. Webb@exeter.ac.uk; Fax: +44 1392 263342; Tel: +44 1392 263334.

S4.1 Sediment and sediment-associated contaminants.

S4.2 Contamination induced by irrigation.



S4.3 Sources and persistence of subsurface contaminants.

S4.4 Modelling point-source pollutants

S4.5 Impact of land and water management on nutrients and eutrophication.

S4.6 Water quality management.

S5 HYDROCHEMISTRY

Convenor: Dr Norman (Jake) Peters,

USGS, 3039 Arwiler Rd., Suite 130, Atlanta, Georgia 30360-2824, USA.
email: nepeters@usgs.gov; Fax: +1 770 903-9199; Tel: +1 770 903-9145.

S5.1 New techniques associated with anthropogenic and natural tracers in understanding hydrological and hydrochemical processes.

S5.2 Salinization.

S5.3 Hydrological processes in the tropics.

S5.4 Contributions of tracer hydrology to modelling.

S6 HUMAN IMPACT ON EROSION AND SEDIMENTATION

Convenor: Prof Des Walling, Department of Geography, University of Exeter, Exeter EX4 4RJ, UK
Fax: +44 1392 263342; Tel: +44 1392 263345.

S6.1 Erosion and sedimentation in a changing environment.

S6.2 The impacts of erosion and sediment control measures.

S6.3 Reservoir sedimentation problems and associated sediment management strategies.

S6.4 Assessing the significance of human impacts on erosion and sediment yields.

WORKSHOPS

W1 SCALING ISSUES IN THE COUPLING OF HYDROLOGICAL AND ATMOSPHERIC MODELS

Convenor: Dr Alfred Becker, Potsdam Inst. for Climate Impact Research, Postfach 601203, Potsdam D-14412, Germany.
Email: becker@pik-potsdam.de; Fax: +49 331 2882600; Tel: +49 331 2882500.

Workshop will be:

W1.1 What scaling techniques are appropriate to be applied in highly heterogeneous landscapes, such as mountainous and semi-arid regions;

W1.2 Under which conditions is it necessary to sub-structure an area into sub-areas of different hydrological behaviour (cut-off, Mosaic Approach);

W1.3 How can statistical distribution functions, topographical indices, and other appropriate characteristics be used

efficiently in spatial scaling;

W1.4 The effect of the computational time step on the representation of nonlinear processes.

W2 KARST HYDROLOGY

Convenor: Dr Chris Leibundgut, Dept of Hydrology, L.A. University, Werderring 4, Freiburg D-79098, Germany.

Email: hydrology@uni-freiburg.de; Fax: +49 761 2033594; Tel: +49 761 2033531.

W2.1 Flow and transport processes in karst aquifers.

W2.2 Recharge of karst aquifers by surface water under arid and semi-arid conditions.

W2.3 Vulnerability and carrying capacity of karst water systems.

W3 MONITORING AND MODELING OF SOIL MOISTURE: INTEGRATION OVER TIME AND SPACE

Convenor: Dr Reinder Feddes, Dept of Water Resources, Agricultural University, Nieuwe Kanaal, Wageningen 6709PA, The Netherlands.

Email:

Reinder.Feddes@users.whh.wau.nl;

Fax: +31 317 484885; Tel: +31 317 482875.

W4 FLOW FORECASTING UNDER CONDITIONS OF LIMITED DATA

Convenor: Dr Jean Claude Olivry, ORSTOM, PB 5045, Montpellier, F-34032, France.

Email: olivry@orstom.orstom.fr; Fax: +33 67 411806; Tel: +33 67 617526.

W5 WATER RESOURCES ASSESSMENT

Convenor: Dr Hugo A Loaiciga, Department of Geography, University of California, Santa Barbara, CA 93106, USA.

Email: hugo@pollux.geog.ucsb.edu; Fax: +1 805 8933146; Tel: +1 805 8938053.

W5.1 Water Resources and Ground Water.

W5.2 Water Resources and Systems Analysis.

W5.3 Water Resources: Sustainable Management.

Runoff computations for water projects

Report on a Symposium held in St. Petersburg, Russia in October-November 1995

The International Symposium "Runoff Computations for Water Projects" held in St. Petersburg, Russia, during 30 October - 3 November, 1995 was organized by UNESCO, the National Committee of Russia for the IHP, the Federal Service of Russia for Hydrometeorology & Environmental Monitoring and the Russian State Hydrological Institute and sponsored by UNESCO, the International Science Foundation and IAHR. It is an established tradition that St. Petersburg, one of the leading European centres in the field of runoff computations, hosts international symposia of this kind. The contributions were from about 25 countries, including most of the Eastern European states and the states of the former USSR, USA, Australia, Israel, India, Sweden, Germany, Switzerland, the Netherlands etc.

The presentations were grouped into four major sessions:

- Use of Runoff Formation Laws for Hydrological Computations.
- Runoff Computations on the Basis of Long-Term Observed Hydrological Series.
- Regional Methods in Hydrological Computations.
- Specific Aspects of Runoff Computations under Anthropogenic Impact.

This grouping was, however, relatively arbitrary and the actual number of issues discussed during the Symposium was much more diverse and covered the aspects of hydrological calculations in large, small, gauged and ungauged

catchments, rural and urban areas, mountain regions and flatlands using deterministic, stochastic and mixed approaches.

An attempt to summarize the main trends in the development of hydrological calculations was made by Rozhdestvensky (Russia). These trends include:

- i) more complete consideration of the initially available hydrological information as well as factors which determine the hydrological characteristic of interest;
- ii) development of new methods which take into account non-stationarity of hydrological time series caused either by anthropogenic activities or by climate change;
- iii) development of methods based primarily on regional data and short-term field hydrometeorological investigations at the point of design.

Several papers concentrated on modelling approaches (from Ukraine, Croatia, USA, Russia, etc.) and described the application of either locally developed or well known models (such as the SSARR model) for generating time series in different physiographic environments (Carpathians, Moldova, Vietnam), predicting the water balance of surface and groundwater resources over large areas (Southern Texas, the Niger Basin) and short-term forecasting of inflow to reservoirs (Croatia). The world-wide experience of the application of the Swedish conceptual HBV model was described by Bergstroem. It was emphasised that although uncalibrated applications require completely physically based

models, the experience accumulated in Sweden demonstrates that a lot can be achieved by a conceptual model with generalized parameters. In Sweden, conceptual models are presently being used in about 400 basins as a supplement to flow measurements. This is similar to the South African experience where the Pitman monthly model has been extensively used for the last few decades in the same way.

Some of the oral presentations and posters concentrated on the use of the method of hydrological analogy for runoff estimations in ungauged river basins. The derivation of objective criteria for the selection of analogue catchments using simplified similarity measures and fuzzy sets theory

were presented in several papers from Poland (Byczkovski et al). Different methods of delineating hydrologically homogeneous regions for the further development of regional regression relationships (for floods and low flows) was widely reported.

The emphasis in many papers was placed on the analysis of non-stationarity of the annual flow time series and the application of models of non-stationary processes for hydrological computations. A number of presentations addressed the issues of improvement of existing national methods for high and low-flow calculations.

Some papers from Belarus and Russia were related to the concept of ecologically safe flows in disturbed rivers, but they were mostly of a rather general nature. The community of South African aquatic scientists seems to be well ahead in this area with the implementation of the Building Block Methodology for the estimation of Instream Flow Requirements.

A report by Grabs (Germany) described the global hydrological database being

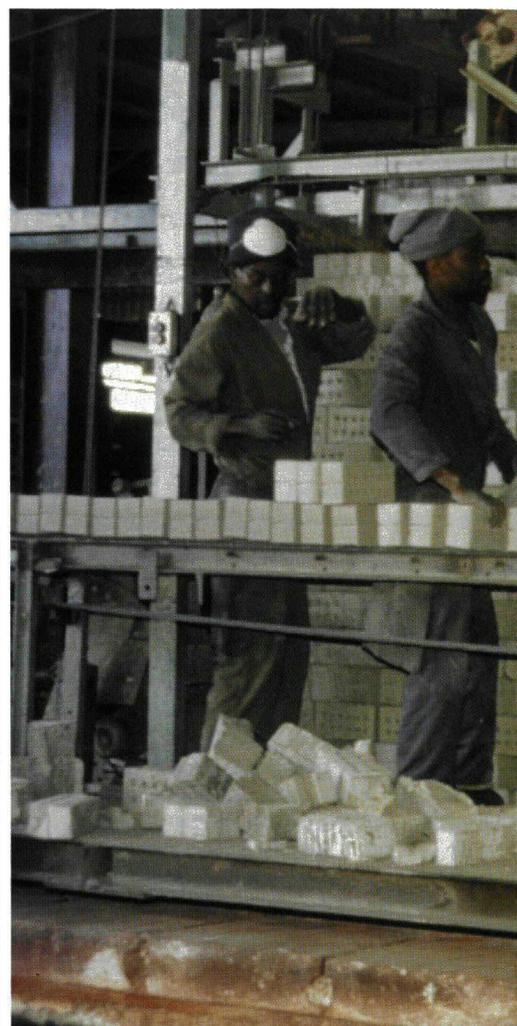
developed in the Global Runoff Data Centre (GRDC). 143 countries (including a number of African states) are contributing to the development of the database which now consists of mean daily and mean monthly discharge data from 3 325 stations monitoring 2 619 rivers worldwide. GRDC participates in regional and global projects contributing to climate modelling, to a global understanding of the hydrological processes and their socio-economic impact. It was emphasised that the flow of information in hydrology can serve as a standard against which the political interest for cooperation in operational hydrology can be measured. Dr. Grabs expressed an interest in the hydrological data analysis routines developed at the Institute for Water Research of

Rhodes University as part of the HYMAS package (HYdrological Modelling Application System).

The Symposium was well organised, but the programme had to be modified on a daily basis since a number of presentations (potentially interesting ones according to the published abstracts) were removed due to the absence of the authors. In some cases the level of actual presentations (not the essence of the papers) unfortunately left a lot to be desired. In spite of all that, the Symposium was an undisputable success since it demonstrated a high level of research in the field of hydrological calculations and provided a good environment for fruitful and sometimes rather hot discussion.

The texts of the oral presentations will be published in the near future probably in one of the 'Red Books' of IAHS.

V. Y. Smakhtin
Institute for Water Research
Rhodes University



Ceramics

A study financed by the Water Research Commission has proved the manufacture of bricks, blocks and tiles from waterworks sludges to be a viable proposition.

According to the final report emanating from the study, sludges and silts produced by South African waterworks and dredging operations often create disposal problems.

Finding a use for such materials could eliminate or reduce these disposal problems, eliminate the spoiling of land or fouling of waterways, reduce disposal costs and create possibilities of financial return from the sale of products produced.



Biobricks have been manufactured using dewatered sewage sludge, while waterworks sludge has been utilised to produce ceramics.

investigation. The major effort of the investigation was focused on overcoming this difficulty. The bricks pressed well in the die, but after being removed from the die for several hours they were prone to cracking. This difficulty has been largely overcome by optimisation studies, the researchers say.

The drying of the pressed tiles and bricks was originally thought to present no difficulties, but eventually it was found that this was the cause of the cracking of the unfired bricks. This was unexpected and very unusual because the drying shrinkage of the bricks was very low and in the case of extruded bricks this would normally never cause such a problem. This difficulty was overcome by perforating the bricks.

In the case of firing it was found that if the bricks or tiles were fired in the normal manner up to the maximum temperature, usually in the range of 900° to 1 000°C, they would crack or warp badly. This difficulty was overcome by introducing a calcination step at 600°C to burn off deflocculants and organic matter.

The firing cycle finally adopted was as follows: one day to reach 600°C from room temperature, left for one day at 600°C, followed by an 80°C rise per hour to reach the required maximum temperature. This solved the problem of the cracking and warping for the tiles and the rings, but not for the solid bricks. It was found that noxious gases evolved in the temperature range of 250°C to 550°C. This could be overcome by venting or scrubbing the gases.

from waterworks sludge

The research was conducted by PS Boucher and JJ van Eeden, both from the Division of Materials Science and Technology (MATTEK) at the CSIR in Pretoria.

The researchers say the main objective of this study was to investigate the technical and economic feasibility of using waterworks sludges from Umgeni Water's Wiggins Waterworks in Durban for the production of bricks, blocks, tiles or possibly other ceramic applications.

Work at MATTEK has identified waterworks sludge as a source of raw material for the production of bricks and tiles. The building elements developed, either

meet or are well below usual production costs.

RESULTS

According to the report severe difficulties were experienced in all critical areas of ceramic processing, i.e. forming, drying and firing. Fortunately, most of these difficulties have been overcome to a greater or lesser extent and valuable experience has been gained in processing waterworks sludge in general.

Whilst the pressing of tiles worked well, the pressing of bricks proved to be the greatest area of difficulty of the whole

Copies of the final report entitled **Investigation of inorganic materials derived from water purification processes for ceramic applications** (WRC report 538/1/95) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 25,00.)

SA WATERKALENDER

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

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

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

Legend:

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

See conferences and symposia pages for events.

Die Waternavorsingskommissie plaas hierdie kalender om te help met die 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

Gids:

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

Sien Konferensies-en Simposiumbladsy vir aangeduide geleenthede.

1996

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1997

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SOUTHERN AFRICA

1996

WATERGEHALTE
MEI 13 - 17

Die Universiteit van Pretoria bied 'n kortkursus in watergehaltebestuur aan.
Navrae: Professor WA Pretorius, Departement Chemiese Ingenieurswese, Afdeling Waterbenutting, Universiteit van Pretoria 0001. Tel: (012) 420-3566.

WISA '96
MAY 20 - 23

The WISA '96 conference will be held at the Feather Market Centre in Port Elizabeth.
Enquiries: Conference Planners, PO Box 82, Irene 1675. Tel (012) 63-1681. Fax (012) 63-1680.

SOIL SCIENCE
JUNE 25 - 27

The 20th Congress of the Soil Science Society of South Africa will be held at the University of the Orange Free State in Bloemfontein.
Theme: Sustainable soil utilisation and rural development.
Enquiries: Chris du Preez. Tel: (051) 401-2957 Fax: (051) 401-2212.

WATER AFRICA
JULY 9 - 12

An exhibition and conference called Water Africa 96 will be held at the Ghana International Trade Fair Centre in Accra.
Enquiries: Zia Howeson. Tel (011) 792-9807 Fax: (011) 791-0571.

WATER ENGINEERING
JULY 18 - 19

The young water, environmental and geotechnical engineers' festival will be held at the Rob Roy Hotel, Botha's Hill, Natal.

Enquiries: Lesley Stephenson, Conference Secretary, PO Box 327, WITS. Tel: (011) 716-5091 Fax: (011) 339-7935.

AQUATIC SYSTEMS
JULY 15 - 19

A conference on aquatic systems will be held at the Elephant Hills Hotel, Victoria Falls, Zimbabwe.
Enquiries: Ms Lesley Stephenson, PO Box 327, WITS 2050. Tel: (011) 716-5091 Fax: (011) 339-7835. E-mail: Stephenson @ egoli.min.wits.ac.za

HYDRAULIC RESEARCH
AUGUST 5 - 7

The International Association for Hydraulic Research - African Division's biennial congress with the theme "From flood to drought" will take place at Sun City.
Enquiries: Miss Genevieve Stephenson, Conference Office, PO Box 327, WITS 2050. Tel (011) 716-5091 Fax (011) 339-7835.

AFRIWATER '96
SEPTEMBER 2 - 5

The AFRIWATER Conference and Exhibition will be held at the Gallagher Estate in Midrand.
Enquiries: Nigel Walker Tel: (011) 318-2009/1189 Fax: (011) 318 1189. International code: (+27 11).

WATERSUIWERING
SEPTEMBER 16 - 20

'n Kortkursus in die bedryf van watersuiweringsaanlegte sal by die Universiteit van Pretoria aangebied word.
Navrae: Professor WA Pretorius, Departement Chemiese Ingenieurswese, Afdeling Waterbenutting, Universiteit van Pretoria 0001. Tel: (012) 420-3566.

ENVIRONMENTAL MANAGEMENT
OCTOBER 7 - 8

The 2nd Environmental Management, Technology and

Development Conference will be held at the Indaba Conference Centre, Fourways, Gauteng.
Enquiries: Lesley Stephenson, Conference Secretary, PO Box 327, WITS 2050. Tel: (011) 716-5091. Fax: (011) 339-7835.

WATERBEHANDELING
OKTOBER 21 - 23

'n Kortkursus oor die behandeling van nywerheids- en verkoelingswater sal by die Universiteit van Pretoria aangebied word.
Navrae: Professor WA Pretorius, Departement Chemiese Ingenieurswese, Afdeling Waterbenutting, Universiteit van Pretoria 0001. Tel: (012) 420-3566.

ISIAME '96
NOVEMBER 4 - 8

An international symposium on industrial applications of the Mössbauer effect will be held in Johannesburg.
Enquiries: Prof Herman Pollak (Chairman), Mössbauer Laboratory, Department of Physics, University of the Witwatersrand, Private Bag 3, Johannesburg 2050. Tel: (011) 716-4053 Fax: (011) 339-8262. E-mail: 005KLKS@ WITSVMA.WITS.AC.ZA

SOUTHERN AFRICA

1997

METEOROLOGY
APRIL 7 - 11

The 5th international conference on southern hemisphere meteorology and oceanography will be held at the University of Pretoria.
Enquiries: Conference Planners: Amie Wissing. Tel and Fax: (012) 46-0170.

OVERSEAS

1996

DRAINAGE
APRIL 21 - 29

The 6th drainage workshop on Drainage and the Environment will be held in Ljubljana, Slovenia.
Enquiries: SDNO-ICID Organising Committee, Biotechnical Faculty, Jamnikarjeva 101, 61000 Ljubljana, Slovenia. Tel: +386-61-123-11-61 Fax: +386-61-123-10-88.

MICROPOLLUTANTS
MAY 6 - 7

A workshop on "Natural origin inorganic micropollutants: arsenic and other constituents" will take place in Vienna, Austria.
Enquiries: Mr Pierre Schulhof, Compagnie Générale des Eaux, Quartier Valmy - 32, Place Ronde, 92982 Paris La Defense CEDEX. Fax: (+33) (1) 46 35 31 50.

GEOFILTERS '96
MAY 29 - 31

The second international conference on Geofilters, addressing new developments and advances in all areas of filtration and drainage will be held in Montreal, Canada.
Enquiries: Geofilters '96, Bureau des Congrès, Ecole Polytechnique de Montreal, CP 6079 succ Centre-ville, Montreal (Qc) H3C3A7, Canada. Tel: (514) 340-3215. Fax: (514) 340-4440.

MONITORING NETWORKS
JUNE 3 - 7

A short course: Design of water quality monitoring networks will be held at the Colorado State University, Fort Collins, USA.
Enquiries: TG Sanders, Environmental Engineering, Departement of Civil Engineering, Colorado State University, Fort Collins, CO 80523. Tel: (303) 491-5448 Fax: (303) 491-7727 E-mail: TGS@Lance.Colostate.Edu

FOREST INDUSTRY WASTE-WATERS

JUNE 10 - 13

The 5th IAWQ symposium on forest industry wastewaters will be held in Vancouver BC, Canada. Enquiries: The organiser, Forest Industry Wastewaters symposium, c/o Venue West Conference Services, 645 the Landing, 375 Water Street, Vancouver BC, Canada, V6B5C6. Tel: +1 604 681 5226. Fax: +1 604 681 2503.

IAWQ

JUNE 23 - 28

The 18th biennial conference and exhibition of the International Association on Water Quality will be held on the tropical island of Singapore. Enquiries: IAWQ, 1 Queen Anne's Gate, London SW1H9BT, England. Tel: 44-171-222-3848. Fax: 44-171-233-1197.

AQUATECH ASIA 96

JUNE 24 - 26

Asia's specialised water technology forum Aquatech '96, will be held at the International Convention & Exhibition Centre in Singapore. Enquiries: RAI, 1 Maritime Square 09-49, World Trade Centre, Singapore 0409. Tel: 65-272-2250. Fax: 65-272-6744.

BIOFILM SYSTEMS

AUGUST 28 - 30

The 3rd international IAWQ special conference on biofilm systems will be held in Copenhagen. Call for papers. Enquiries: Institute of Environmental Science & Engineering, Att: Mia Clausen, Building 115, Technical University of Denmark, DK-2800 Lyngby, Denmark. Tel: +45 45 9339 08 Fax: +45 45 9328 50.

MONITORING TAILOR MADE

SEPTEMBER 9 - 12

The second international workshop on information strategies in water management will be held in

Nunspeet, the Netherlands. Enquiries: Workshop Secretariat, Buerweg 51, 1861 CH Bergen, the Netherlands. Tel: +31 72 5899062 Fax: +31 72 5899040.

IRRIGATION

SEPTEMBER 15 - 22

The 16th International Congress on Irrigation and Drainage will be held in Cairo, Egypt. Enquiries: The Organising Committee, Drainage Research Institute, National Water Research Centre, Delta Barrage, PO Box 13621/5, Cairo, Egypt. Tel: (202) 21 89 383 or (202) 21 88 941 Fax: (202) 21 89 153.

WASTEWATER TREATMENT

SEPTEMBER 23 - 25

The IAWQ-NVA conference on advanced wastewater treatment, nutrient removal and anaerobic processes will be held in Amsterdam, the Netherlands. Enquiries: Conference Secretariat, Buerweg 51, 1861 CH Bergen, the Netherlands. Tel: +31 725 899062 Fax: +31 725 899040.

WATER QUALITY

SEPTEMBER 26 - 27

The European Water Pollution Control Association in cooperation with the Netherlands Association on Water Management is organising an international conference on The Future Water Quality Management in Europe. The conference will be held in the RAI Conference Centre in Amsterdam, the Netherlands. Enquiries: The Conference Secretariat, Buerweg 51, 1861 CH Bergen, the Netherlands. Tel: +31 725 899062 Fax: +31 725 899040.

WATER HONG KONG '96

NOVEMBER 11 - 17

The 10th IWSA-ASPAC regional conference and exhibition will be held in Hong Kong. Call for papers. Enquiries: Technical Sub-committee, Water Hong Kong '96, c/o Water Supplies Department, 48/F

Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong. (Attention: Ms Daisy S M HO). Fax: (852) 2824 0578 Tel: (852) 2829 4444.

HAZARDOUS MATERIALS

JUNE 11 - 13

A waste managers training course on the management of hazardous materials will be held at the Colorado State University, USA. Enquiries: TG Sanders, Environmental Engineering, Departement of Civil Engineering, Colorado State University, Fort Collins, CO 80523. Tel: (303) 491-5448 Fax: (303) 491-7727 E-mail: TGS@Lance.Colostate.Edu

POLLUTION

JUNE 22

The US EPA will present a Pollution prevention speciality course from 8:30 to 16:30 at Singapore Polytechnic. Enquiries: Mr Ang Fui Gan. Tel: 870 6163 Fax: 772 1973 E-mail: FGAng@sp.sc.sg

IAWQ

JUNE 23 - 28

The 18th biennial conference and exhibition of the International Association on Water Quality will be held on the tropical island of Singapore. Enquiries: IAWQ, 1 Queen Anne's Gate, London SW1H9BT, England. Tel: 44-171-222-3848. Fax: 44-171-233-1197.

AQUATECH ASIA 96

JUNE 24 - 26

Asia's specialised water technology forum Aquatech '96, will be held at the International Convention & Exhibition Centre in Singapore. Enquiries: RAI, 1 Maritime Square 09-49, World Trade Centre, Singapore 0409. Tel: 65-272-2250. Fax: 65-272-6744.

ACTIVATED SLUDGE

JUNE 24 - 28

The 8th annual short course on Activated sludge process control will be held at the Colorado

State University, Fort Collins, USA. Enquiries: TG Sanders, Environmental Engineering, Departement of Civil Engineering, Colorado State University, Fort Collins, CO 80523. Tel: (303) 491-5448 Fax: (303) 491-7727 E-mail: TGS@Lance.Colostate.Edu

WASTEWATER

JUNE 27 - 28

An IAWQ post-conference seminar on industrial wastewater management will be held at the Singapore Marriott Hotel. Fees: US\$450. Enquiries: Binnie & Partners (Singapore), 31 Exeter Road, #15-01/02 Singapore 239732. Tel: 738-4022 Fax: 738-2717.

BIOFILM SYSTEMS

AUGUST 28 - 30

The 3rd international IAWQ special conference on biofilm systems will be held in Copenhagen. Enquiries: Institute of Environmental Science & Engineering, Att: Mia Clausen, Building 115, Technical University of Denmark, DK-2800 Lyngby, Denmark. Tel: +45 45 9339 08 Fax: +45 45 9328 50.

STORM DRAINAGE

SEPTEMBER 9 - 13

The 7th international conference on urban storm drainage will be held in Hannover, Germany. Enquiries: Prof F Sieker: Institut für Wasserwirtschaft, Universität Hannover, Appelstrasse 9a, D-3000 Hannover 1, Germany. Tel: +49-511-7623567 Fax: +49-511-762-3456

MONITORING TAILOR MADE

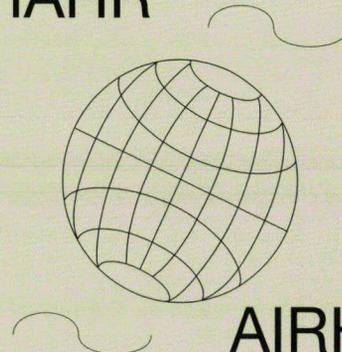
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from
flood
to
drought

International Association for Hydraulic Research
African Division

IAHR



AIRH

BIENNIAL CONGRESS

5-7 August 1996

at

The Lost City, Sun City, South Africa

CONGRESS THEMES

- Flood to Drought - problems of temporal distribution
- Water Transfer Schemes
- Environmental aspects of water use in arid regions
- Innovative methods of conserving water

WORKSHOP THEMES

- Research and education needs in Africa in hydraulics and water
- Financial and political constraints of water developments
- The Zambesi River - present and future

For further information please contact:

Genevieve Stephenson, Conference Office, PO Box 327, WITS 2050, South Africa
Tel (27) (011) 716-5091, Fax (27) (011) 339-7835

20th Congress of the Soil Science Society of South Africa

20ste Kongres van die Grondkundevereniging van Suid-Afrika

Wanneer 25 - 27 Junie 1996
When 25 - 27 June 1996

Plek **Place**

Universiteit van die Oranje-Vrystaat, Bloemfontein

University of the Orange Free State, Bloemfontein

Tema **Theme**

Volhoubare grondgebruik en landelike ontwikkeling

Sustainable soil utilisation and rural development

Programinhoud

Programme content

Meer as 30 mondelinge en meer as 20 plakkaatreferate sal aangebied word.

More than 30 oral and more than 20 poster papers will be presented.

Ekskursie

Excursion

'n Ekskursie word vir die Maandag 24 Junie beplan. Daar word beoog om 'n ekstensiewe mielie- en koringplaas naby Hoopstad te besoek waar die boer baie goed daarin slaag om grondverdigting op te hef, winderosie te bekamp en water op te gaar. Die fabriek van ACO, waar van die grootste trekkers in die wêreld vervaardig word, gaan ook besoek word.

An excursion is planned for Monday 24 June. The intention is to visit an extensive maize and wheat farm near Hoopstad where the farmer succeeds in reducing soil compaction, combating wind erosion and conserving water. The factory of ACO, where some of the world's largest tractors are manufactured, will also be visited.

Sosiale funksies

Social functions

Behalwe vir die formele dinee op Donderdagaand, beoog die reëlingskomitee 'n skemeronthaal vir die Dinsdagaand en 'n braai vir die Woensdagaand.

Apart from the formal dinner on Thursday evening, the organising committee plans a cocktail for the Tuesday evening and a braai for the Wednesday evening.

Akkomodasie

Accommodation

Koshuisverblyf is vanaf Sondag beskikbaar vir persone wat daarvan gebruik wil maak. Besonderhede oor hotelle en gastehuse waar u u eie besprekings moet doen, kan vanaf die organiseerders verkry word.

Hostel accommodation is available at the University from the Sunday for persons who want to make use of it. Details of hotels and guest houses at which delegates should make their own reservations are available from the organisers.

Registrasie

Registration

Die registrasiefooi beloop R500.

The registration fee is R500.

Navrae/Enquiries:

Navrae/Enquiries:

Organisatoriese aspekte/Organisational aspects

Programme Content/Programinhoud

Elize Rall Tel. (051) 4012425 Fax (051) 306714
(08:30-12:00)

Chris du Preez Tel. (051) 4012957 Fax (051) 4012212