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THE WATER WHEEL 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.

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New Sludge Treatment Technology Benefits Environment and Saves Millions

"Reduce, Reuse, Recycle" – that's the slogan of the War on Waste campaign, and the City of Cape Town has gone to great lengths to put it into practice, even applying it to human waste. Sue Matthews tells the story.

A state-of-the-art sludge dewatering and drying plant, which cost R60 million and took two years to build, has recently come on line at the Cape Flats Wastewater Treatment Works, the largest sewage works in the Cape Metropolitan Area. The new technology not only *reduces* the amount of treated sludge requiring disposal, but also incorporates innovative *recycling* methods to reduce fuel consumption, and allows the sludge to be *reused* as an economically valuable product.

The Cape Flats Wastewater Treatment Works, which lies alongside Zeekoevlei, close to the False Bay coastline, was commissioned in 1980. It was designed for a maximum incoming flow of 200 million litres of wastewater per day, and today it runs at about 80% capacity. Initially most of the sludge was discharged into hollows in the surrounding dunes, but as space

The Cape Flats Wastewater Treatment Works

became limiting it became necessary to dispose of it at more distant landfill sites. Apart from increasingly prohibitive transport costs, it wasn't long before concerns were raised about the pressure on the city's landfills, as well as potential health risks and groundwater contamination.

"Clearly, this was not a sustainable or environmentally acceptable way of dealing with the sludge," says Kevin Fawcett, Head of Wastewater Operations (South) at the City of Cape Town, "so we started investigating the latest treatment technology."

A team of municipal engineers embarked on a fact-finding tour of wastewater sludge handling and drying installations in Europe, and soon realised that South Africa was lagging behind other countries in implementing good sludge management practices.

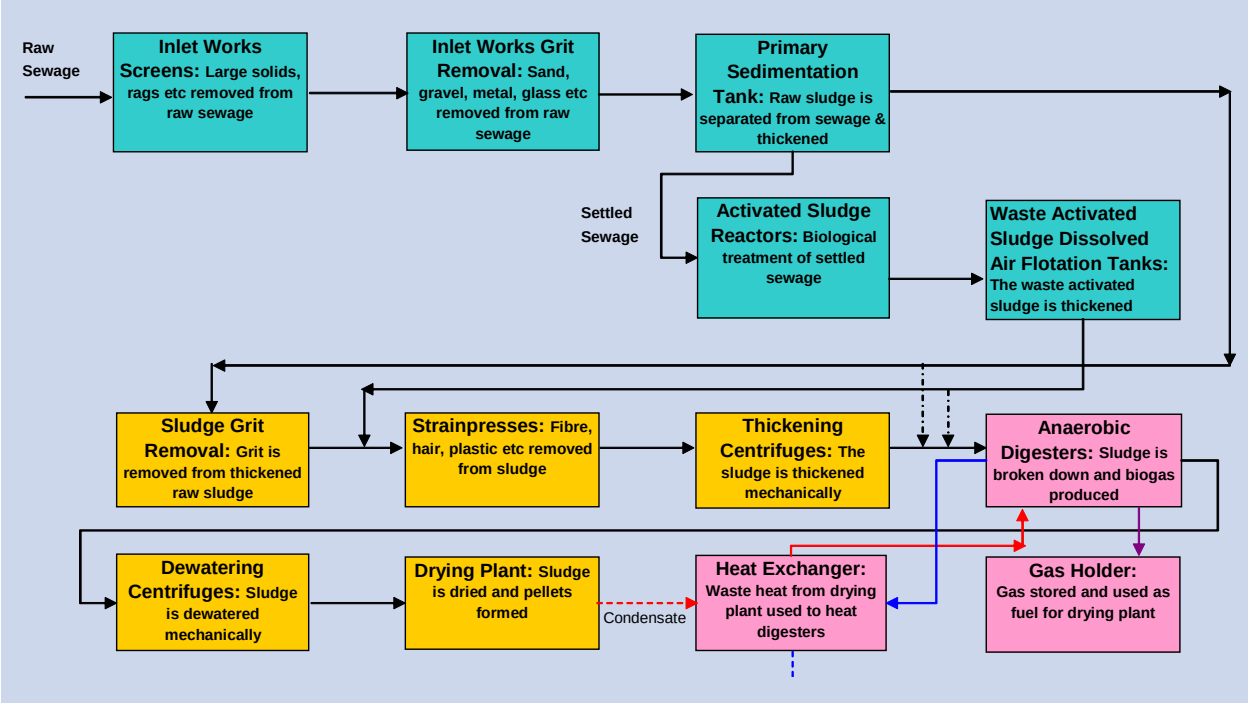
"The technology we eventually decided upon has been around for 15 years, but we're the first to bring it into this country for sludge treatment – although something similar is already being used in the fishmeal industry here," says Mr Fawcett.

The option chosen as the most suitable and cost-effective for the Cape Flats Wastewater Treatment Works was the Swiss Combi system of direct thermal sludge drying after centrifugal thickening and dewatering, as this could be used in conjunction with the existing waste-activated sludge dissolved air-flotation plant, primary sedimentation tanks and anaerobic digesters. Local consortium, Biwater-Murray and Roberts JV, was awarded the tender to build the plant, and will also operate and maintain it for the first five years.

In short, the new plant's process is as follows: sludge is thickened in two centrifuges before being fed into three 6 000 m^3 digesters to reduce the solids concentration, after which it passes through another two centrifuges for dewatering. This dewatered, digested sludge is then conveyed to the drying plant, where hot air evaporates the water content. Finally, the dried sludge is screened to separate it into fine and coarse grain sizes, producing two size classes of pellets. The small pellets are fed back into the system as seed material for pellet formation (they serve as a dry core that becomes coated with wet sludge), while the large pellets are bagged as the end-product.

Centrifuges for sludge thickening and dewatering

Final product - the sludge pellets are pathogen-free



Simplified diagram of the wastewater and sludge treatment process in Cape Town

Implementation of the new technology has reduced the volume of sludge requiring disposal from 2 000 m^3 to about 50 m^3 of bagged pellets per day.

"Apart from being beneficial from an environmental standpoint, this has a huge economic pay-off, because disposal costs and transport to landfills amounts to about R1 800 per 10 m^3 of sludge," says Mr Fawcett.

The plant will also save R10-15 million per year on fuel costs, thanks to a novel recycling system. The methane "biogas" produced in the anaerobic digesters is stored on site in a 2 000 m^3 gas holder, and used to fuel a combustion chamber that generates the heat required for drying purposes. Although the combustion chamber can also run on diesel, the biogas is enough to meet all the drying plant's fuel requirements. An added bonus is that waste heat from the drying plant is in turn used to heat the anaerobic digesters to the 38°C required for optimal biogas production.

"……it's fair to say that the Cape Flats Wastewater Treatment Works are producing the cleanest, safest sludge in the country"

This ingenious feedback loop ensures that the overall thermal efficiency of the works is maximised. But the real beauty of the new technology is that the sludge pellets have a number of practical uses. Indeed, in terms of the new DWAF Sludge Disposal Guidelines, they qualify for Type D classification, allowing unrestricted use.

The City of Cape Town intends calling for tenders for the utilisation and/or disposal of the pellets soon, but two potential applications are in the brick and cement manufacturing industries. The pellets have a high calorific value, so can be used as a fuel source in place of the normal low-grade coal.

More noteworthy, perhaps, is that they could also be used as a fertiliser or soil supplement, and it was for this reason that a pellet size of 2-4 mm was chosen – to facilitate their use in standard agricultural spreaders. The pellets retain all of the beneficial, nutrient-rich properties of human manure, but bear none of the aesthetic and health concerns normally associated with sewage sludge.

"The pellets are 100% pathogen-free," says Biwater's Adrian Cooney, "and I think it's fair to say that the Cape Flats Wastewater Treatment Works are producing the cleanest, safest sludge in the country."

WRC Meets Southern Africa's Agricultural Needs

- by Edith Webster -

Ongoing and completed research funded by the Water Research Commission (WRC) is well on its way to meeting some of the agricultural needs identified by the New Partnership for Africa's Development (NEPAD) during the World Summit on Sustainable Development.

NEPAD sees, according to *Water and Sustainable Development in Africa: An African Position Paper*, "tremendous opportunities to stabilise and improve rainfed agricultural production through rainwater harvesting, low-cost micro-irrigation technologies and better land management".

"What is important here," continues the document, "is to understand that Africa needs to take a broad and innovative approach to mobilising water for agricultural production".

The WRC's Key Strategic Area of Water Utilisation in Agriculture focuses on:

- increasing the efficiency of water use for food, fibre, wood and timber production (improving the knowledge of biological, technical and economic processes of production);
- ensuring sustainable water resource use in rainfed and irrigated areas (improving the knowledge of natural processes and man-induced impacts of resource use); and
- increasing household food security and profitability of farming and, thereby, the livelihoods of people dependent on agriculture (improving the knowledge of management processes of people who are using water).

NEPAD

Extract from *Water and Sustainable Development in Africa: An African Position Paper* (published on behalf of the Africa Water Task Force by the International Water Management Institute).

"Africa faces daunting socio-economic problems that threaten to marginalise the continent from the growing process of globalisation, and finds itself caught in a trap that confines it to a vicious cycle of underdevelopment, conflict and suffering. The New Partnership for Africa's Development (NEPAD) is Africa's response to this threat. It has been launched by African heads of state as a bold attempt to free Africa from this trap and launch it on a path of sustainable development."

Dr Gerhard Backeberg, the WRC's director: Water Utilisation in Agriculture, says it is imperative that the utilisation and development of water resources in agriculture are analysed in relation to the needs and requirements of people.

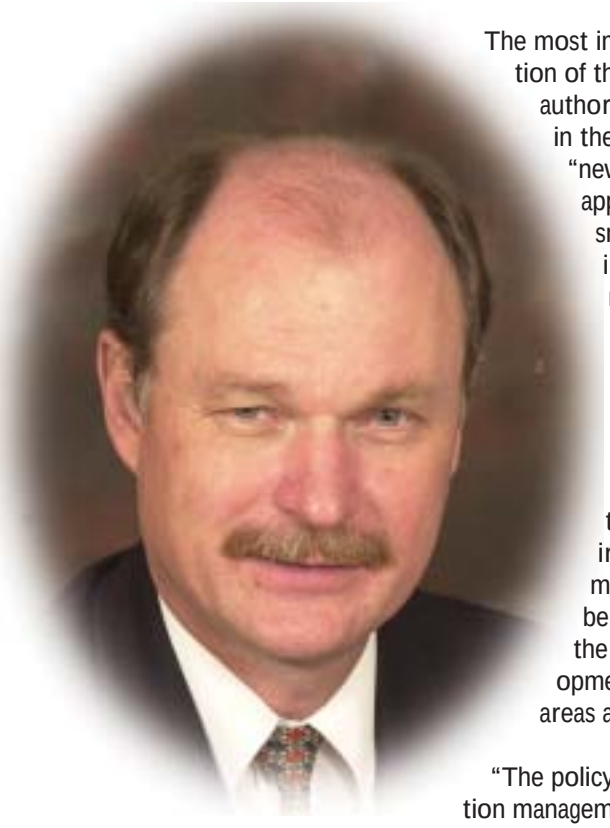
"People using water in agriculture comprise a diverse group of subsistence, emerging and commercial farmers within interrelated subsectors, including irrigated and dryland agriculture," he explains, adding that the point of departure of applied research is, therefore, the real-life problems experienced, primarily, by water users and related organisations for irrigated and rainfed crop production, fuelwood and timber production as well as livestock and fish production.

"Research as a problem-solving process must provide information, technologies and models, which can be applied by present and future generations of water users," continues Dr Backeberg.

The WRC's overall objectives, therefore, include initiation of research to enable the utilisation of scarce water resources efficiently, beneficially and sustainably to increase household food security and farming profitability and, thereby, increase economic and social welfare through efficient growth and equitable distribution of wealth on a farming, local community and regional level.

WHAT IS THE WRC DOING TO REALISE ITS OBJECTIVES?

In one direction, research is being conducted on water utilisation for food and fibre production by improving the knowledge of the processes of field, horticultural and industrial crop production. This involves a programme aimed at water-efficient production methods in relation to soils, crops and technology in rainfed and irrigated agriculture.



Dr Gerhard Backeberg of the Water Research Commission

"Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires an understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment used and the method of production followed. Research on all these aspects can contribute to higher water-use efficiency in agriculture," says Dr Backeberg.

The WRC's *Review of planning and design procedures applicable to small-scale farmer irrigation projects* (by CT Crosby, M de Lange, CM Stimie and I van der Stoep) evaluates the technical aspects of irrigation practised by subsistence and emerging farmers, and establishes ground rules for design methods and norms for effective planning and application of irrigation in development.

The most important contribution of this research, say the authors, has been its role in the development of a "new" participatory approach to planning small-scale farmer irrigation, which has received official recognition and is being implemented.

This research finds a paradigm shift in the approach to irrigation development, which should be viewed in terms of the economic development of deep rural areas as a whole.

"The policy is one of irrigation management transfer to the farmers on existing schemes. In the past, irrigation projects were treated as 'islands of development' in the communal land tenure areas, and they failed. Now, there must be a co-ordinated approach to land tenure, resettlement, rehabilitation, civil and traditional governance, Water User Associations, finance, infrastructure development, and marketing before irrigation management transfer can become a reality."

Another relevant activity of the WRC is its research on water utilisation for poverty reduction and wealth creation in agriculture, which explains Dr Backeberg, is geared towards improving the management processes undertaken by people using water. Here one of the programmes focuses on sustainable water-based agricultural activities in rural communities.

"Poverty, hunger and malnutrition among rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rainfed and irrigated crop production," Dr Backeberg points out.

"Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research, which improves knowledge, farming skills and leadership capabilities," he adds.

To this end, the WRC is researching the application of globally-identified technologies in the local agricultural environment.

In the *Evaluation of the appropriateness and management requirements of micro-irrigation systems in small-scale farming* (by WRC-funded researchers FJ du Plessis and I van der Stoep) the practical application possibilities of micro- and drip-irrigation by small-scale farmers are investigated – by installing and monitoring a number of systems on farms, under the management and control of small-scale farmers, as well as field visits to several systems operated by individual farmers and various existing micro-irrigation schemes.

Du Plessis and Van der Stoep conclude that micro-irrigation could be implemented successfully in small-scale farming, provided a number of support services are in place.

"Small-scale farmers experience very few problems with the operation of the system, provided it functions properly and operational guidelines are followed satisfactorily."

The authors of *Micro-irrigation for smallholders: guidelines for funders,*

planners, designers and support staff in South Africa (FJ du Plessis, W van Averbeke and I van der Stoep) find that micro-irrigation has some distinct advantages, when compared with conventional surface and overhead systems, for small-scale farming conditions. These advantages include:

- high efficiency and the potential to save water;
- relatively low operating pressure;
- low labour requirements;
- day and night operation;
- versatility in field layout and adaptability to topography; as well as
- relatively easy movement of equipment between fields.

Researchers investigated the practical application possibilities of micro- and drip-irrigation by small-scale farmers

WHAT IS MICRO-IRRIGATION?

Micro-irrigation, according to the abovementioned publication, is a collective term for irrigation with drippers (drip irrigation) and micro sprayers (micro-spray irrigation). In both cases, only part of the soil surface is normally wetted. Irrigation takes place regularly (a short cycle is followed) and the discharge of the emitters is relatively low compared to other types of irrigation. Micro-irrigation typically requires low operating pressures and enables high irrigation efficiencies.

These researchers identify three important social factors determining the success of smallholder micro-irrigation:

The role of farming in the livelihood strategy of the farming household. Where farming forms part of a multiple livelihood strategy, and other sources of income buffer the impact of setbacks on the farm, successful micro-irrigation is less likely than in cases where the household is heavily dependent on farm income for survival. The team, therefore, concludes that an analysis of the livelihoods of farmers needs to form part of irrigation planning.

"Research as a problem-solving process must provide information, technologies and models, which can be applied by present and future generations of water users"

The person or people responsible for daily farming activities. Whereas the head of the household is responsible for decisions on the farm, another member of the family or hired help often conducts work on the farm. The person who executes farming activities needs to be a prime target for training. An analysis of the relationship between this person and the head of the household is important, especially in terms of the rewards the person receives for working on the farm. When the rewards are perceived to be inadequate, it is likely that this person will leave the farm as soon as a more rewarding opportunity presents itself. Whenever this happens there is usually a collapse of the micro-irrigation enterprise (gone with the person is the knowledge of the enterprise). In cases where a person other than the household head is responsible for day-to-day farming, it is important to extend training to more than just that person.

The relationship of the farming household with the community. Close relationships with other community members allow farmers to claim time and expertise from some of these members. Teachers, for example, are approached to explain

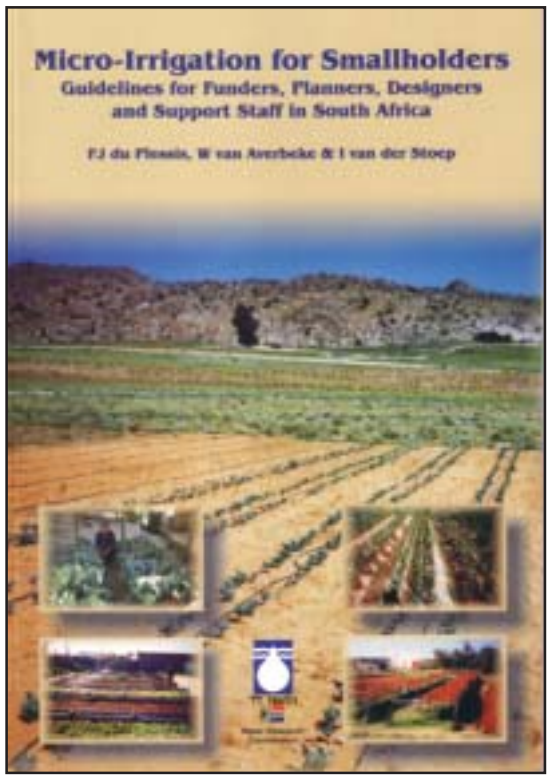
written information or act as translators. Where farmers relate well to their community, the situation is generally more favourable for farming, particularly for micro-irrigation.

WHERE TO NOW?

Research that formed these guidelines, cautions Dr Backeberg, shows micro-irrigation is not a panacea for all the limitations and constraints of smallholder irrigation. Quoting from the report, he continues: "On occasion, the installation of micro-irrigation on a smallholding leaves farmers worse off than they were before. This emphasises the need for careful planning by the engineer or designer of the system. Before encouraging smallholders to invest in a micro-irrigation system, there is a need to assess the full range of factors, which combine into an overall degree of risk. Only when the degree of risk is manageable and accepted by the farmer should planning and design of the project proceed."

Among the technical factors affecting successful smallholder micro-irrigation, mentions Dr Backeberg, adequacy and reliability of the water supply have been identified as the most critical. "Among the human factors, training is the most critical. In several cases, lack of training causes project failure".

For most, adds Dr Backeberg (again quoting from the report), "participation in the initiation, development and implementation of a micro-irrigation project represents a period of intense learning. Farmers, particularly, are exposed to a wide range of unfamiliar concepts during this period. Building the farmers' confidence throughout this learning process is important for long-term success. The trainer plays an important role in supporting the process – the trainer must carefully tailor the programme to the evolving needs of the farmer". He says the guidelines are aimed at providing trainers with insight into the range of important issues associated with micro-irrigation, and helping them decide on the content of their programmes.



The following research reports (relevant to this article) can be obtained from the Water Research Commission, Private Bag X03, Gezina, 0031:

- **Report TT164/01**: *Micro-irrigation for smallholders: guidelines for funders, planners, designers and support staff in South Africa*
- **Report 768/1/01**: *Evaluation of the appropriateness and management requirements of micro-irrigation systems in small-scale farming*
- **Report 578/2/00**: *A review of planning and design procedures applicable to small-scale farmer irrigation projects*
- **Report 689/1/00**: *Irrigation requirements of selected crops under small-scale production: linking on-farm and on-station research*
- **Report 774/1/00**: *Developing sustainable small-scale farmer irrigation in poor rural communities: guidelines and checklists for trainers and development facilitators*

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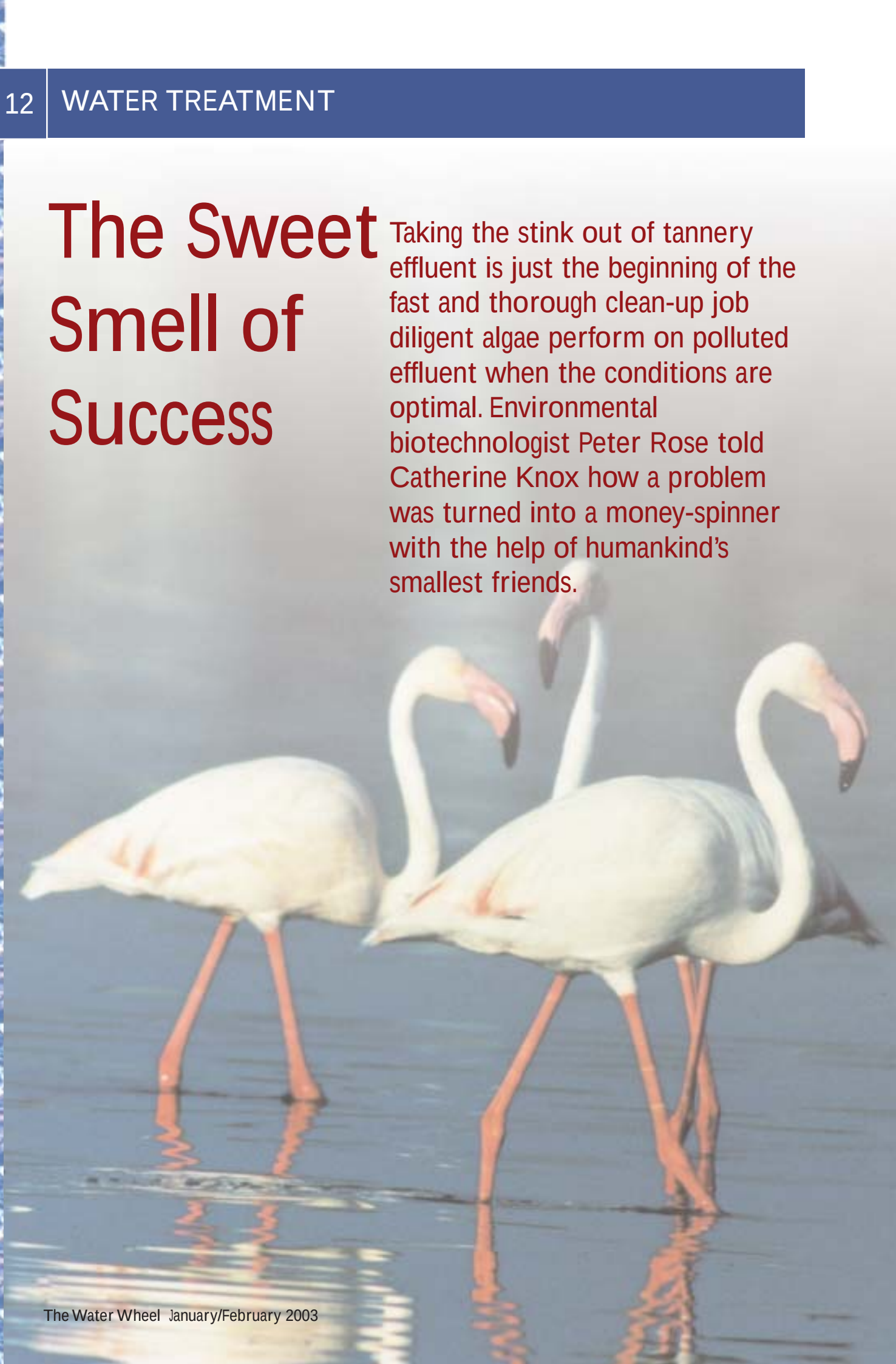
The Sweet Smell of Success

Taking the stink out of tannery effluent is just the beginning of the fast and thorough clean-up job diligent algae perform on polluted effluent when the conditions are optimal. Environmental biotechnologist Peter Rose told Catherine Knox how a problem was turned into a money-spinner with the help of humankind's smallest friends.



Part two of a series of good news water stories taken from Peter Rose's 12-volume report on an integrated WRC-funded project. Prof Rose is the director of Rhodes University's Environmental Biotechnology Unit. (Note that the article on the biological remediation of sewage and acid minewater mentioned in the last issue of Water Wheel will appear in a forthcoming issue).

People don't call Wellington "Smellington" anymore, even though the local tannery is still in operation. What changed? Rhodes University's Environmental Biotechnology Group, headed by Prof Peter Rose, got to work and proved that if natural systems are allowed to operate at full-strength problems can be turned into opportunities.
Today, instead of a stink, a rich harvest of *Spirulina* is produced in the tannery ponds.

Bad smells are one of nature's ways of warning people about toxins and the suffocating sulphurous miasma that emanated from old-style tannery waste stabilisation ponds announced a worst-case scenario of the pollutants that may be encountered in this kind of pond system, says Peter Rose.

Tannery effluent contains a range of components including heavy metals and high levels of sulphate, ammonia, nitrates and protein nitrogen. Which is precisely why Rose and his group chose to start here in their quest for a sustainable and integrated wastewater beneficiation technology suitable for a variety of applications.

The waste stabilisation ponds at Mossop-Western Leather tannery near Wellington was identified as a good example of a model environmental-scale bioreactor system. The waste stabilisation ponding used for many years in the tanning industry offers a low-cost, quasi-passive system relying on microbial action to "digest" pollutants. But nature was clearly taking the strain at the Wellington tannery. When the team started work on site, they came upon a sad pile of crumpled pink feathers: a dead flamingo.

A detailed study of the microbe ecology in the ponds revealed the dominance of *Spirulina* and *Dunaliella* species in near mono-

An impressive paddle wheel keeps the water flowing steadily round the 2 500 m² high rate algal pond at the Wellington tannery where Spirulina *biomass is produced commercially today.*

The pilot plant at Wellington featured high rate algal ponds scaled down to 80 m² (just under one third of the size of the full-sized operational pond).

A PERK FOR PERLEMOEN

When it became apparent that a significant mass of *Spirulina* would be the by-product of the bioremediation of tannery effluent, Peter Rose approached Peter Britz, head of Ichthyology and Fisheries Science at Rhodes University. Would *Spirulina* be useful in aquaculture? was the question Rose posed. *Spirulina* is already widely recognised as a human dietary supplement and has proved its worth in cattle feed as well.

A young perlemoen (abalone) nibbles at an offering of Spirulina-*rich Abfeed*

Britz and his group found that *Spirulina* harvested from a tannery ponding system was a high-value food additive that complied with aquaculture nutritional standards. Tests on day-old chicks produced no adverse results, proving that pesticide residues and heavy metals were within prescribed levels. "We found that a *Spirulina*-rich diet enhanced the colour of goldfish and of rainbow trout. The trout meat was also improved," says Britz. But there was more commercial significance in successfully adding *Spirulina* to Abfeed, the ration concocted by Rhodes scientists for use in commercial abalone farming. If a big and steady supply of *Spirulina* were available it would a standard ingredient of Abfeed, says Britz.

cultures and at different stages in the increasing salinity gradient as the evaporation process progressed from pond to pond. This led to the development of a *Spirulina*-high rate algal pond to optimise and intensify the function of the algae. An added benefit of the high rate ponds is that it occupies only 10% of the footprint of a waste stabilisation system.

In the high rate algal ponds, an association is established between high populations of algae and micro-organisms that eat organic matter, with the production of oxygen (through photosynthesis) providing for the breakdown of organic substances in the water and the algae in turn using the inorganic nutrients (such as sulphates).

In optimal conditions the algae not only functioned more efficiently, they also bloomed, fixing solar energy as biomass, and floating rafts of algae capped the effluent waters, reducing the smell. Rose and his colleagues were also able to develop and test membranes suitable for straining out and thus harvesting value-laden *Spirulina* biomass.

As yet another bonus, water that had been treated in the *Spirulina*-high rate algal pond was clean enough to be returned to the tannery for use in certain stages of production.

Once a pilot-scale system had been tested a full-size operation was commissioned. Not long afterwards, a flock of flamingoes occupied the ponding system – a sure sign of a healthy and naturally-functioning saline aquatic ecosystem. Rose was so moved by the grace with which Nature approved his efforts that he adopted the flamingo as the emblem for his group's quest.

The work had proved to the team that integrated algal ponding systems might indeed offer opportunities for a more general approach to saline wastewater treatment. And without delay, they set to work following up on the *Dunaliella* species they had found in the hyper-saline water in the ponds at the end of the cascade.

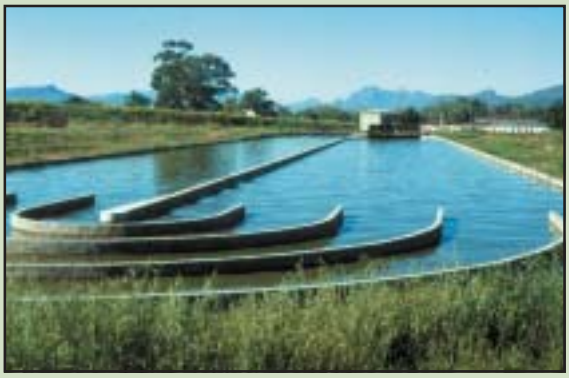
***Next issue**: Harvesting cancer-fighting beta-carotene as part of soda-ash production in Botswana.*

HOME, SWEET HOME, FOR *SPIRULINA*

Len Dekker and an assistant harvesting Spirulina *biomass*

The Mossop Tannery project produced a healthy crop of young scientists: a number of postgraduate students grew to professional maturity as they worked under Prof Rose's supervision. Len Dekker was one of them, Kevin Dunn another. A leading member of the team, Dunn is about to launch his own independent consultancy specialising in algal biotechnology with a strong environmental slant. He and Rose are planning to collaborate on further projects in the future.

TOPPING UP SA'S SCIENTIST POOL



The 2 500 m^2 *Spirulina* high-rate algal pond which was constructed as part of the full-scale integrated algal ponding system to treat tannery wastewaters at Mossop-Western Leathers at Wellington. This and five of the series of waste stabilisation ponds are currently used by Gerald Tutt's firm, Eco-aqua, to produce high-quality *Spirulina* biomass. Tutt says, "If it weren't for Prof Rose's work, no one would have realised you could farm *Spirulina* here." Ironically, Tutt has to feed his *Spirulina* as operations at the tannery have changed so the effluent produced is less saline and no longer contains sufficient nutrients for the algae.

COLOUR-CODED MICROBES AT WORK

The dark green colour of ponds where *Spirulina* bloomed are clearly visible in this aerial shot taken of the waste stabilisation ponds at the tannery near Wellington at the time Peter Rose's Environmental Biotechnology Group started work there. The first five ponds in the cascade are at the top end in the picture. The dark brown-grey colour of the raw tannery effluent changed to bright pink and then purple in these ponds because of the changing dominance of microbial populations. The effluent was then pumped to the pond at the bottom end and from there back through the successive ponds towards the middle. The dark red-brown colour of the bottom two ponds was produced by purple sulphur and non-sulphur bacteria. The green ponds were near the end of the cascade and thus contained a high concentration of salinity and nutrients due to the progressive process of evaporation. The salinity and nutrient load in the last two ponds was high enough to support small blooms of *Dunaliella salina* and *Dunaliella viridis* – the beta-carotene-producing organisms which were to be the subject of a subsequent Environmental Biotechnology Group project.

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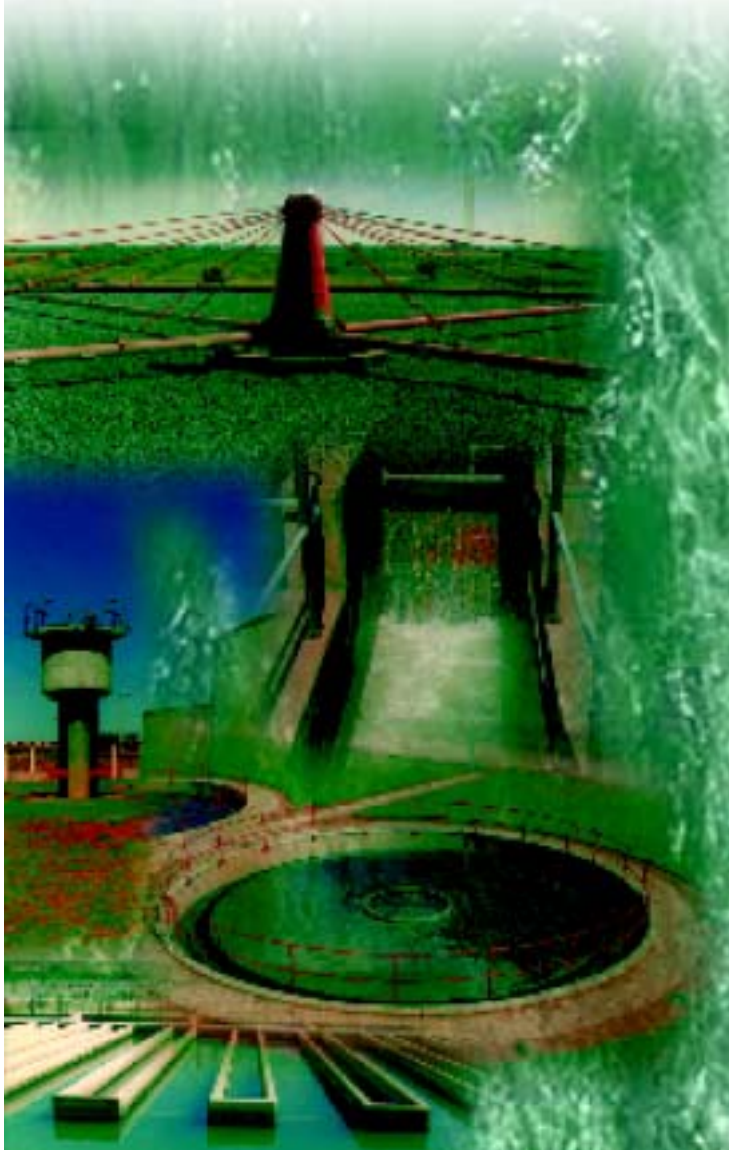

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- Nitrate
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- Sulphate
- COD
- OA
- Settleable solids / suspended solids / total solids
- SVI (MLSS)
- Principles of colorimetry / spectrophotometry
- Phosphorous (PO_4^{3-}; Total phosphate)
- Nitrite-nitrogen
- Chlorine (Free chlorine, total chlorine)
- Kjeldahl digestions
- NH_3 (NH_4^+)
- TKN

WATER QUALITY MANAGEMENT IN THE NEW MILLENNIUM - QUO VADIS

Cost: R 5 500 per candidate (R5 000 if paid by 20 April 2003 and 24 October 2003respectively)

Dates: 13 to 16 May 2003, 18 to 21 November 2003

Course contents:

- Pollution Control versus Water Quality Management
- What a Water Quality Manager needs to know about the:
  - National Water Act
  - National Environmental Act
  - Minerals Act
- Licensing Procedure
- Reserve Determination
- Integrated Water Resource Management
- Catchment Management Agencies
- Resource Directed Measures
- Background to Catchment Management
- Basic Water Quality Chemistry
- Discussion on a selection of water quality related matters
- Case Studies

OPERATION OF BIOLOGICAL FILTERS

Cost: R 4 700 per candidate

Dates: 19- 23 May 2003

Course contents:

- Sources of wastewater
- Composition of wastewater
- Process description and microbiology
- Types of biological filters
- Operational aspects: (Loading rates, recycle rates, etc.)
- Operational problems
- Disinfection
- Anaerobic digestion of waste sludge

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Your Water Meters Are Your Cash Registers

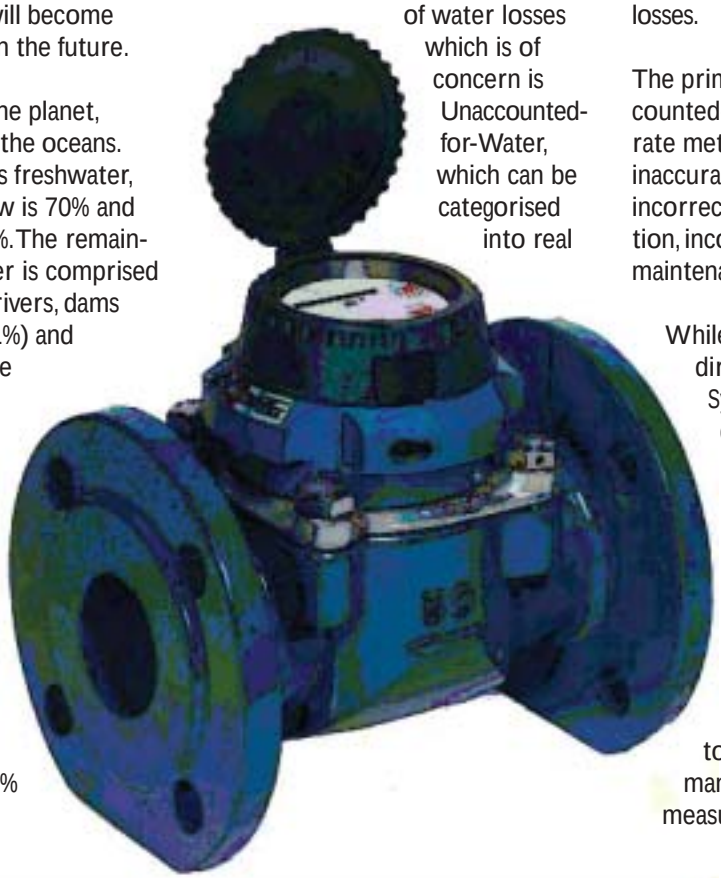
Water shortages has always been a major problem in South Africa, and one which will continue to provide challenges as the resource becomes scarce, especially with the impact of global warming. In addition, inefficient use and wastage of water directly contributes to the situation. For a water services institution this water loss usually translates into lost revenue. Indeed, it has been said that "Your water meters are your cash registers." It is imperative, therefore, to fully understand the significance of accurate meter reading as a leading factor in water demand management and revenue generation. Deleen Wilson reports.

A United Nations study suggests that South Africa will have between 25 and 50% less surface water available by 2080, while a study by the Department of Water Affairs and Forestry indicates we will have run out of fresh water by 2020, should we continue to use water the way we do. Despite government's intention of providing drinking water for all in the next ten years, unless we stop wasting it, this task will become much more difficult in the future.

Of all the water on the planet, 96.5% is saltwater in the oceans. The remaining 3.5% is freshwater, of which ice and snow is 70% and groundwater is 29.6%. The remaining 0.4% of freshwater is comprised of the world's lakes, rivers, dams (0.26%), biomass (0.1%) and atmospheric moisture (0.004%). These figures highlight the issue of water scarcity.

Water is a socio-economic resource and it provides municipalities with a constant revenue stream. However, between 25% and 50% of water supplied via reticulation systems is not accounted or charged for, encouraging wastage and reducing the income it generates. Yet, with good management, these unacceptably high losses can be reduced by up to half, providing substantial improvements in income generated and encouraging water demand management.

In potable water distribution systems, the main component of water losses which is of concern is Unaccounted-for-Water, which can be categorised into real and apparent losses. Real losses include leakage, pipe bursts, flushing, overflows, etc, while apparent losses are inaccurate measurements and the inaccurate reading of meters. It is not possible to effectively manage real losses until steps have been taken to manage the non-physical losses, as inaccurate measurements create a "garbage in - garbage out" scenario, and can result in incorrect actions being taken to curb the real losses.



The primary culprit of Unaccounted-for-Water is often inaccurate meters. The main reasons for inaccuracy are incorrect selection, incorrect sizing, incorrect installation, incorrect reading and lack of maintenance.

While Basil Bold, managing director of Invensys Metering Systems, South Africa - a division of the world's largest manufacturer of water meters, attributes the quote, "To measure is to know", to a Greek philosopher, he has unashamedly - and with only slightly tongue-in-cheek - adapted it to read, "To measure accurately is to know". Says Bold, "Good management begins with good measurement and no successful

Common installation problems causing waste and lost revenue

Insufficient straight pipe - perfect air trap

Dirt box too close to the meter

A very poor installation - bends in both the horizontal and vertical plane

business can operate effectively without good measurement. This is particularly true of water management, where accurate measurement of flows is fundamental to curbing waste and generating income."

When addressing apparent losses, international water management companies adopt the 80/20 rule, whereby 20% of your customers (bulk water meters) generate 80% of the revenue. For example, 80% of Alberton's revenue is generated from only one consumer, and in Athens, 22 000 bulk meters (1.2%) generate 40% of the revenue.

INCORRECT METER SELECTION

Meter selection and management are generally neglected and given a low priority. This often leads to higher apparent losses. A key issue is not necessarily meter accuracy, but measuring range, or the turn-down ratio. A way of comparing the measuring range of bulk meters is to divide the minimum flow rate at which the meter will hold a given accuracy limit, into the flow rate at which the meter can be operated continuously at the stated accuracy. This is expressed as a ratio, e.g. 128:1, and is known as the turn-down ratio. The higher the ratio, the better the device.

Although accuracy must always be a key consideration, most reputable mechanical meters will exceed the generally accepted accuracy standard of ISO 4064 or OIML R49. The achievement of a ±2% error limit is not the issue: critically important is the flow range over which the device will maintain this accuracy. ISO 4064 performance standard for water meters is over 22 years old.

The main reasons for inaccuracy are incorrect selection, incorrect sizing, incorrect installation, incorrect reading and lack of maintenance

Water meter design and materials of construction have progressed exponentially since the standard was drawn up, and modern meters are now capable of exceeding the minimum performance standard specified by 200% and more. It is not sufficient to simply state that the "meters must comply with ISO 4064". Engineers need to compare the relative performance envelopes of different manufacturers, to ensure that they are getting good measuring value for their money.

The outward appearance of meters shows little evidence of change over the years, yet internally technology has advanced substantially, with the improvements to bulk mechanical meters typically providing the new generation with improved hydraulic geometry, a hydro-dynamically balanced rotors, and innovations such as multi-point calibration, which have substantially increased the range over which they can measure accurately. The larger manufacturers introduced bulk meters incorporating the latest technology some five years ago, during which time we have seen in excess of a 400% improvement in measuring performance, with turndown ratios typically increasing from 30:1 to 128:1.

FACTORS INFLUENCING METER SELECTION

A number of elements influence the selection of the correct meter for the job, including the measuring range, accuracy, durability, straight pipe requirements, price, upgrade path (AMR capability), cost/availability of a reliable power source (electronic meters), after-sales support, and the supplier's track record. The selection of suitable meters is not simply a matter of the cheapest price. Unfortunately, many water supply authorities sacrifice

quality and correct selection in favour of quantity, but the short-term financial savings are offset by the meter's lifespan of poor performance.

INCORRECTLY SIZED METERS

This is the major contributing factor towards apparent water loss. Mechanical meters are generally sized to match the pipe diameter, which is a fundamental error as it results in oversizing and an inability to measure low flows. Meter change-out programmes offer quick financial returns for the minimum amount of investment and effort.

AUTOMATIC METER READER

The latest development within the water meter industry is the much hailed and fastest moving technology related to bulk water meters, Automatic Meter Reading (AMR). The AMR removes the primary issues related to manual meter reading, including "hit & miss" reading cycles, incorrect readings, transcribing errors (e.g. x10, x100 errors), and the problem of manipulation and corruption.

The older generation of water meter registers were encapsulated in plastic and, therefore, not waterproof. The latest AMR registers are encapsulated within a glass/copper enclosure making it waterproof to IP 68 and, thus, finally allowing it to accommodate electronic intelligence. It is this - and not simply a remote reading via a pulse output - that has opened up the world of AMR.

"Your water meters are your cash registers, silently generating revenue day and night, if they are measuring accurately"

AMR meters can be read in a number of ways, including an inductive pad using a hand-held computer, "walk-about or "drive-by" radio read or even by cell phone. AMR also brings with it a hardly noticable change, but one of major significance - the fact that mechanical meters may now be flooded or buried without fear of malfunction, which makes them infinitely more resistant to vandalism. Flooded meter pits lead to recurring costly meter reading problems or, more commonly, lack of meter reading problems. Advanced register design and AMR technology negates these problems, saves money and resolves the major problem of insufficient straight pipe up and downstream of the meter when installed in an inverted U configuration.

Mechanical bulk meters require unobstructed straight pipe upstream and downstream of the meter to ensure accuracy. The amount of straight pipe required is dependent on the meter type and design, with some meters requiring less than others. Generally, a minimum length of five pipe diameters upstream and three pipe diameters downstream is required. The WS meter is the only bulk Woltman meter that requires no straight pipe upstream or downstream of the meter as the flow profile is conditioned within the meter.

Bold concludes, "Your water meters are your cash registers, silently generating revenue day and night, if they are measuring accurately." Simply by fitting the correct meter, your cash registers could be ringing with even more vigour !

CASE STUDY

SABESP São Paulo, Brazil - Pilot Project (1997)

Currently, the SABESP (São Paulo, Brazil) risk/reward contract is the largest contract in process anywhere in the world, the value of which exceeds $ 20million dollars. SABESP supplies water to 22 million people in São Paulo state. They experienced a progressive deterioration in their bulk consumer billing meters, which were their primary revenue generators.

354 bulk consumer meters were selected for change-out, of which six were under-sized (larger meters were fitted), 248 (70%) were over-sized (these were inaccurate at low flows and smaller meters were fitted - oversized bulk water meters are a worldwide phenomenon.), and 100 were correctly sized, but not necessarily accurate (these meters were renewed and re-calibrated, or replaced totally).

Sophisticated optimal sizing and maintenance software was undertaken, which provided a number of options over the full range of performance, from theoretical to empirical. These options include purely theoretical meter sizing, based on flow rate design parameters for a zone, district, or end user; semi-theoretical, using information such as billing records; and empirical, making use of logged data. Associated software matches the expected flow profile at a given location to the meter providing the best overall accuracy, and performs a financial analysis to determine whether the selected meter will produce a positive return on investment.

São Paulo - SABESP supplies water to 22 million people in São Paulo state

PAYBACK

The average payback period was two months, although in 83 cases it was actually less than one month. Payback was calculated on the total capital outlay on each meter installed i.e.:

- Cost of the initial evaluation to determine the correct meter type and size - utilising meter sizing software and logging (where necessary)
- Cost of the replacement meter
- Cost of removal of the old meter and installation of the new meter.

The costs are weighed up against the expected increased revenue derived from better measuring accuracy and measuring range. A meter change-out programme begins with the analysis of the billing records and the meter data base, but cannot be successfully implemented without site inspections and prioritisation.

A second critical component of a successful operation is follow-up reading and logging. This ensures that the project stays on track and that the change-outs are being selected and sized correctly, in order to produce a maximum return.

PROJECT UPDATE AS OF JANUARY 2002

• Total estimated meter replacement	26 711
• Meters replaced to date	16 809
• Number of meters replaced undersized	720 (4%)
• Number of meters replaced oversized	14 278 (85%)
• Number of meters - no size change	1 811 (11%)

The results to date have confirmed the findings of the initial pilot study. 85% of all meters were oversized, resulting in substantial revenue losses at low flows. In excess of 100 meters are being changed out daily, and the additional revenue generated has exceeded all expectations.

SIZE/PAYBACK RELATIONSHIP

Greater focus should be placed on the large diameter meters in a reticulation system. Because of the high volumes metered, small measurement errors result in large volume errors and large potential financial losses.

Example

300 mm meter @ ½ Qn	= 700 m³/h
In one month will measure	= 504 000 m³/month
2% error	= 10 080 m³/month
@ + /-R2.50/m³	= R25 200/month
Cost of replacement (say)	= R15 000
Payback period	= 18 days

Viewpoint

Southern African Water Conflicts: Are They Inevitable or Preventable?

*By Dr Peter Ashton**

The role of water in virtually all of the water-related disputes or conflicts that have occurred in southern Africa has been secondary to considerations of territorial sovereignty. In most cases, these disputes have been driven by perceptions that the territorial integrity or sovereignty of one country is compromised or threatened by the claims of a neighbouring territory. Many of the international boundaries in southern Africa are aligned with rivers and water courses; the locations of these boundaries are the legacies of surveys and treaties conducted by earlier colonial powers. However, because rivers are dynamic systems that frequently change their courses in response to flood events, we can anticipate future disputes over the precise locations of international boundaries when rivers change their shape and configuration.

We can also anticipate that almost all future disputes or conflicts involving water, or concerned with some aspect of water, will tend to be local in scale. These conflicts will be amenable to institutional and government intervention and the rights and responsibilities of individuals are well protected in national legislation. At the international scale of a water-based conflict or dispute between two or more countries, some principles of international law provide a solid foundation for negotiation and arbitration. However, it is clearly in the interests of individuals and societies that appropriate national and international institutions should jointly develop management plans for shared river basins and also derive workable protocols that can be used to prevent water-based conflicts in the region.

ARE WATER CONFLICTS INEVITABLE?

The Sedudu Island case study (see box) clearly shows how current geographical and geo-political realities, together with prevailing social and economic trends, provide conditions that can promote or accentuate water-based conflicts in southern Africa. We have also seen how natural patterns of change in aquatic systems can lead to disputes or can accentuate existing conflict situations. We now need to seek answers to the question: "Are all or some of these potential water conflicts inevitable?"

The simplest direct answer is an unequivocal "Yes"; however, this answer is conditional on several factors. Simply put, and without being pessimistic, *water conflicts are inevitable if we continue to do nothing to prevent them from occurring*. Whilst this response may appear to be rather simplistic, it is guided and framed by the key insight that the finite fresh water resources that are available in the sub-continent cannot continue indefinitely to support the escalating demands that we make of them. Competition for the available water supplies will continue to increase to a point where radical interventions are required. In addition, water conflicts that are linked to the positions of international borders will still occur in those places where the countries concerned have not yet reached joint agreements.

A critically important issue in this debate is the realisation that the relative 'scale' or size of the problem has a definite bearing on the range of options that are available to prevent disputes or conflicts over water. For example, at small (or local) scales, the individuals or communities who disagree with one another over the access to, or use of, a water source have fewer conflict prevention options available to them. This is in distinct contrast to situations at larger (national and international) scales, where international treaties, accords and laws, as well as independent mediation, are available to countries to prevent or resolve conflict situations.

Whilst water is very unlikely to be the direct or only cause of a war in southern Africa, it is very likely that water will become a contributing factor to regional instability as demands for water approach the limits of the available supplies. Inevitably, water disputes will occur first in those areas where water is in shortest supply; these will then

*Dr Peter Ashton is from the Division of Water, Environment & Forestry Technology, CSIR, PO Box 395, Pretoria 0001. E-mail: pashton@csir.co.za. *The article first appeared on the* Science in Africa *website in November 2002.*

tend to spread further afield as more and more of the scarce water resources are used directly or transferred further afield to meet rising demands.

In the light of these observations, it is important for everyone concerned to consider the potential preventive approaches that are available so that we can properly formulate and implement suitable policies, strategies and actions to avoid the prospect of water-based conflicts and their adverse consequences in southern Africa.

A Southern African Example - The Kasikili Island in the Chobe River

Disputed ownership of Sedudu/Kasikili Island in the Chobe River (Namibia and Botswana)

The ownership of Sedudu/Kasikili Island in the Chobe River has been the subject of a formal dispute between the governments of Namibia and Botswana since 1996, when both governments agreed to submit their claims for sovereignty of the island to the International Court of Justice (ICJ) in The Hague. Prior to this formalisation of the dispute, the "ownership" of Sedudu/Kasikili Island had been disputed by local residents in Namibia and Botswana, as well as preceding colonial governments, since the Berlin Treaty of 1 July 1890. A brief outline of the grounds for the dispute has been drawn from the official press communiqué that announced the International Court of Justice's decision to recognise the territorial claims of Botswana.

The island known as "Sedudu" in Botswana and "Kasikili" in Namibia, is approximately 3.5 km^2 in area and is located in the Chobe River. The Chobe River divides around the island, flowing to the north and south, and the island is flooded to varying depths for between three and four months each year, (usually beginning in March), following seasonal rains.

On 29 May 1996, both Namibia and Botswana jointly submitted their cases for territorial sovereignty of Sedudu/Kasikili Island to the ICJ, asking the Court for a ruling based on the Anglo-German Berlin Treaty of 1890 and the principles of International Law.

The historical origins of the dispute are contained in the Berlin Treaty of 1890, when the eastern boundaries of the Caprivi Strip along the Chobe River were defined in very vague terms as "the middle of the main channel" of the Chobe River, so as to separate the spheres of influence of Germany and Great Britain. In the opinion of the ICJ, therefore, the dispute centred on the precise location of the "main channel". Botswana contended that this is the channel running to the north of the island, whilst Namibia contended that the channel to the south of the island was the main channel. Since the terms of the Berlin Treaty did not define the location of the channel, the Court proceeded to determine which of the two channels could properly be considered to be the "main channel".

In order to achieve this, the ICJ considered both the dimensions (depth and width) of the two channels and the relative volumes of water flowing within these two channels, as well as the bed profile configuration and the navigability of each channel. The Court considered submissions made by both parties as well as information obtained from *in situ* surveys during different periods of seasonal flow. Against the background of the object and purpose of the Berlin Treaty, as well as the subsequent practices of the parties to the Treaty, the Court found that neither of the two countries had reached any prior agreement as to the interpretation of the Treaty nor the application of its provisions.

In reaching its verdict, the Court also considered Namibian claims that local Namibian residents from the Caprivi area had periodically occupied Sedudu/Kasikili Island, since the beginning of the twentieth century, depending on seasonal circumstances as well as river flows and inundation levels. The Court considered that this occupation could not be seen to reflect the functional act of a state authority, even though Namibia regarded this "occupation" as the basis for claims for "historical occupation" of the island. The Court also found that this so-called "occupation" of Sedudu/Kasikili Island by Namibian residents was with the full knowledge and acceptance of the Botswana authorities and its predecessors.

The final Court ruling was given in favour of Botswana, with the ICJ indicating that the northern channel around Sedudu/Kasikili Island would henceforth be considered as the "main" channel of the Chobe River. Accordingly, the formal boundary between Namibia and Botswana would henceforth be located in the northern channel of the Chobe River. Botswana and Namibia have agreed that craft from both countries will be allowed unimpeded navigation in both the northern and southern channels around Sedudu/Kasikili Island.

(to page 24)

The ICJ ruling is very welcome after a relatively long period of protracted debate and intermittent threats of military action, including formal military occupation of the island by the Botswana Defence Force. The Sedudu/Kasikili Island dispute provides an excellent example of a water-based conflict situation that reached a high level of tension, preventing resolution of the problem by the disputing parties, thus requiring an independent third party (the ICJ) to be called in to arbitrate the dispute. However, it is important for us to note that, like *all* other rivers, the Chobe River is a dynamic system where the shape and position of its channels will change over time. Natural processes of sediment deposition and erosion will continue to occur, each depending on the flow patterns in the river. Therefore, it is inevitable that the Chobe River will continue gradually to alter the position and configuration of its main channel in the future. Future changes in the position or shape of the main channel could possibly become a source of future dispute between the two countries.

In this example, the primary dispute between the two countries was one of territorial sovereignty rather than about access to water or to water-dependent resources. However, water is the physical driving force for changes to the aquatic system that forms the territorial boundary. Unless these two countries jointly develop a formal protocol to address this type of situation, similar cases of "water-related conflict" can be expected to occur in future.

There are still five islands in the Caprivi sector whose territorial sovereignty or "ownership" is contested; three of these islands are in the Chobe River and two are in the Zambezi River. Without wishing to pre-empt any options that may be considered by the countries concerned, we can anticipate that the legal principles upon which any decision will be based are likely to follow the same principles and logic used to resolve the dispute over Sedudu/Kasikili Island.

Good Neighbour Agreements on South Africa's Shared Watercourses

Tony van der Watt summarises the Department of Water Affairs and Forestry's viewpoint

Just as "no man is an island unto himself", so too, no nation within an economic region can prosper in isolation. This is recognised in the existence of the Southern African Development Community (SADC), the overall objective of which is "the attainment of an integrated regional economy on the basis of balance, equity and mutual benefit for all member states".

Three key development objectives have been identified as the basis for an integrated regional economy in Southern Africa, namely poverty alleviation, food security and industrial development [1]. Fundamental to the achievement of these goals, is the sufficient availability of water throughout the region. It enables food production, hygiene, industry, power generation, environmental diversity and indeed life itself. No regional or national development can take shape, economic prosperity be achieved or reasonable standard of living sustained, without giving primary consideration to water.

An inescapable fact of life for South Africa is that four major river systems arise within or flow across this country, are utilised by its people for a variety of purposes, but are also the concern of other upstream or downstream nations. These are the Limpopo, which is shared between South Africa, Botswana, Zimbabwe and Mozambique; the Incomati and Maputo Rivers, which rise in South Africa, with Swaziland and Mozambique as downstream users; and the 2 300 km long Orange River, the basin of which covers the whole of Lesotho and (including the Vaal River catchment) half of South Africa, as well as a small part of southern Botswana and the southern part of Namibia.

This gives relevance to the warning by Dr Peter Ashton of the CSIR's Division of Water, Environment and Forestry Technology, in this issue of Water Wheel, that water conflicts are inevitable if nothing is done to prevent them from occurring. Fortunately, bilateral foundations exist between South Africa and its neighbour states on the management of their respective shared watercourses, leading up to a Protocol on

Shared Watercourses in the SADC Region (1995), followed by an Agreement between the Governments of Botswana, Lesotho, Namibia and South Africa on the establishment of the Orange-Senqu River Commission.

The Protocol recognises the UN Convention on the uses of international watercourses, the UN Conference on Environment and Development, the socio-economic development programmes in the SADC Region and their impact on the environment, the desire for close co-operation for judicious, sustainable and co-ordinated utilisation of the shared watercourses in the Region, and the need for development of their resources to support sustainable socio-economic development.

A useful background document on the watercourses that South Africa shares with its neighbours is the paper entitled "Implications of Protocol on Shared Watercourse Systems in the SADC Region", delivered by M S Basson as the SA Country Paper on Shared Watercourse Systems at the SADC Water Week Workshop in Pretoria in September 1999. The paper provides an overview of the relevant shared watercourses and elements of potential conflict, as well as suggestions for improved co-operation between the various users of water in the Region.

Briefly summarised, Basson's observations are:

ELEMENTS OF POTENTIAL CONFLICT

A prominent element of potential conflict lies in the population growth of the area and consequent shrinkage of water per capita for domestic needs and economic growth, with social and environmental impacts.

Incompatible priorities and perspectives between countries regarding the use of water could also lead to conflict, particularly as the point of full resource utilisation is reached.

Mozambique, as the most downstream country of three shared river systems, has already expressed concern on several occasions about upstream developments. One complaint is that reduced freshwater flow into the ocean has caused damage to coral reefs and prawn banks in Mozambique, and seawater intrusion into some rivers.

Incompatible legislation and technological approaches may also lead to misunderstanding, suspicion and different perspectives between countries concerning the efficiency of water use and resource management.

Basson's observations on the various shared river systems in which South Africa has an interest, briefly summarised, are as follows:

LIMPOPO RIVER SYSTEM

Water use from the Limpopo system in South Africa is dominated by irrigation (about 50%) with mining, industrial and domestic use accounting for the rest. There is a further great need to provide domestic water supplies to some millions of people in under-developed areas of Limpopo Province.

Additional essential usage of water from the Limpopo basin is made by Botswana and Zimbabwe. It is furthermore vital to provide a sufficient supply of high quality water to maintain the delicate ecosystems of the Kruger National Park. This then leaves Mozambique, with its interest in expanding its irrigation and domestic water supplies, in the unenviable situation of being the most downstream user on the Limpopo.

With all three upstream countries in dire need of utilising their water resources, a careful balance needs to be achieved to ensure the equitable apportionment of water to Mozambique, and to maintain the ecology of the river and its important tributaries, some of which suffer from water quality problems due to upstream usage.

International co-operation with respect to the management of this watercourse system is overseen by the Limpopo Permanent Technical Committee, representing South Africa, Botswana, Zimbabwe and Mozambique.

INCOMATI AND MAPUTO RIVER SYSTEMS

The Incomati River basin (of which the Sabie River is an important tributary) feeds through the north of Swaziland into Mozambique, and the Maputo River basin (of which the Usutu and Pongola Rivers are important tributaries) feeds around the south of Swaziland into Mozambique.

Meeting the requirements of the exploding population along the upper reaches of the Sabie River, with its need for additional irrigation and domestic water, would impact on delicate ecosystems in the Kruger National Park and on Corumana Dam in Mozambique. Extensive upstream usage would also impact on Mozambique's need to supply water to the city of Maputo from the Incomati River.

The upper reaches of the Maputo River's tributaries in South Africa and Swaziland also face demands for urban water supplies and power generation, as well as for additional interbasin transfer to the Vaal River. The perceived lack of effectiveness of flood control at Pongolapoort Dam in South Africa has been a contentious issue with Mozambique in the past. Sufficient water also needs to be released from this dam to maintain water supply and ecosystems in Mozambique.

In respect of the Incomati basin, bilateral regulatory authorities have

existed between South Africa and Swaziland, and between South Africa and Mozambique respectively. In respect of the Maputo basin, a tripartite technical committee formed the point of contact between the three countries involved. These agreements have now been merged into the Incomaputo Agreement on Water Sharing, which was signed at the World Summit on Sustainable Development in Johannesburg in August 2002.

ORANGE RIVER SYSTEM

Four countries have an interest or potential interest in the Orange River system, namely South Africa, which contributes 55% of the total natural runoff of 11 200 million cubic metres per year, Lesotho 41% and Namibia 4%. No runoff from Botswana has been known to have reached the Orange River in recent times.

Several bilateral agreements and institutional arrangements on the Orange River have been entered into between South Africa and its co-basin neighbours. These include the Lesotho Highlands Water Commission, the Agreement on the Lesotho Highlands Water Project and the Trans-Caledon Tunnel Authority, between South Africa and Lesotho, the Permanent Water Committee between South Africa and Namibia, and the Joint Permanent Technical Committee between South Africa and Botswana. The bilateral agreements culminate in (but are not replaced by) an agreement between all four countries (South Africa, Lesotho, Botswana and Namibia) to establish the Orange-Senqu River Commission. The basic objective of the Commission is to provide technical advice to the four parties on the development, utilisation and conservation of water resources in the river system.

ECOLOGICAL CONSERVATION

Besides the direct human dependence on the abovementioned shared river systems, which is the concern of the SADC, a further vital aspect (which the SADC takes into account) is the need to conserve their ecology in order to support sustainable socio-economic development for the future[2].

Interbasin transfers have various physical, environmental, technical and resource management impacts on the watercourse systems involved.

Basson notes that effluent return flows, as well as highly saline mine pumpage, are exerting a significant impact on the water quality of the Vaal River downstream of urban centres. He also notes that water quality along the lower Orange River is still good, but that the transfer of water from the Senqu River (upper Orange River in Lesotho) to the Vaal River, combined with lower-quality flows from the Vaal River into the Orange River, as well as irrigation return flows, are having an effect.

FUTURE CO-OPERATION

In his paper, Basson pays tribute to the good co-operation achieved on trans-boundary rivers in the past, through the bilateral channels between the various countries. However, the Protocol on Shared Watercourse Systems in the SADC Region provides a much wider base for a comprehensive multi-sectoral approach to international co-operation.

Some key elements towards facilitating the goals of the Protocol, in which South Africa could play a leading role, are the harmonisation of strategies and concerted efforts at basin, national, regional, sectoral and international level, with recognition of water as a key, but limited, natural resource.

To ensure equitable sharing of the resource, there is a need to identify and agree upon water-use priorities and allocation criteria – in particular, trade-offs between users. There is a need to pro-actively address the situation of water requirements exceeding the availability of water, and attention needs to be given to specific interbasin water transfer considerations.

Harmonisation is also needed in respect of environmental standards and resource management (sharing of technology and databases), leading to common insights and understanding and a common knowledge base among SADC states, as well in the legal and institutional arrangements between the participating countries.

Ideally, the natural resources of the SADC regions should be subjected to holistic perspectives to determine their comparative and competitive advantages and identify obstacles to development. This study should include natural, human and financial resources together with factors such as climate, infrastructure and technology, and how these could best be utilised towards achieving the common regional goals. Such an exercise would also give rise to principles for the optimum utilisation and sharing of water.

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1 *Implications of Protocol on Shared Watercourse Systems in the SADC Region, M S Basson, SA Country Paper on Shared Watercourse Systems, SADC Water Week Workshop, Pretoria, 16 September 1999.*

2 *Revised Protocol on Shared Watercourses in the SADC region.*

SOUTHERN AFRICA & AFRICA 2003

ENVIRONMENTAL COURSES

A series of environmental courses on the new environmental law, implementing environmental management systems and audits, water quality management, environmental risk assessment, air quality management, the legal framework for managing water in South Africa, etc will be held throughout the year by CEM (the Centre for Environmental Management) at the University of Potchefstroom (PU for CHE).
Enquiries: Mrs Dydre Greeff/Mrs Madel Lottering.
Tel: (018) 299 2714 or (018) 299 2725.
Fax: (018) 299-2726.
E-mail: aokdg@puknet.puk.ac.za or aokml@puknet.puk.ac.za
Website: http://www.puk.ac.za/education/shortcourses/environment.html

WATER TREATMENT
MARCH 31 - APRIL 2

The 5th WISA Membrane Technical Division (MTD) workshop will be held at the Vaal River Resorts, Gauteng.
Enquiries: Dr Andre Maartens,
PO Box 2264, Evander 2280
Tel: 082 326 3820
E-mail: amaartens@buckman.com

FLOODS
APRIL 2 - 4

A three-day short course on floods and stormwater will be held at the Institute for Water and Environmental Engineering, Department of Civil Engineering, University of Stellenbosch. Topics include: River hydraulics and sediment transport, Flood hydrology, Reservoir sedimentation and channel deformation, Dealing with litter, Stormwater and the environment, Road drainage, Coastal flooding and Information technology applications.
Enquiries: Mrs Estelle Hettasch.
Tel: (021) 808 2100
Fax: (021) 808 4351
E-mail: hettasch@sun.ac.za

ENVIRONMENTAL MANAGEMENT
MAY 6 - 8 & OCTOBER 7 - 9

A short course on environmental management will be held at the Post-Graduate Centre of the University of Pretoria.
Enquiries: Ms Marina Nell.
Tel: (012) 420 5010.
Fax: (012) 362 5285.
E-mail: marina.ce@up.ac.za

WATER QUALITY
MAY 19 - 21

A course in SASS5 – a rapid method of water quality assessment – will be held at Merry Pebbles in Sabie, Mpumalanga. For more information, see page 31 in this magazine.

WASTE MANAGEMENT
MAY 20 - 21

A short course on waste management will be held at the Post-Graduate Centre of the University of Pretoria.
Enquiries: Ms Marina Nell.
Tel: (012) 420 5010.
Fax: (012) 362 5285.
E-mail: marina.ce@up.ac.za

SASAQS/ZSSA
JUNE 29 - JULY 4

A joint conference of the Southern African Association of Aquatic Scientists and the Zoological Society of Southern Africa will be held at the University of Cape Town.
Enquiries: Mrs H Battle
Tel: (021) 650 3603
Fax: (021) 650 3301
E-mail: hbattle@botzoo.uct.ac.za
Website: http://www.wetandwildlife.uct.ac.za

HYDROLOGY
SEPTEMBER 3 - 5

The 11th South African national hydrology symposium and workshop will be held at the PE Technikon in Port Elizabeth, Eastern Cape. The theme will be: "Water resources in Southern Africa – the future is not what it used to be!"
Enquiries: Juanita McLean.
Tel: (046) 6224014
Fax: (046) 622 9427
E-mail: juanita@iwr.ru.ac.za
Website: http://www.ru.ac.za/institutes/iwr/S

SANCIAHS2003
SEPTEMBER 3 - 5

The 11th South African National Hydrology Symposium will be organised by the Department of Civil Engineering, PE Technikon and the Institute for Water Research, Rhodes University and will be held at the PE Technikon, Port Elizabeth. The theme will be "Water resources in Southern Africa - The future is not what it used to be!" Further details are available from the IWR website (http://www.ru.ac.za/institutes/iwr/SANCIAHS2003).
Enquiries: Juanita McLean
Tel: +27 (0)46 6224014.
Fax: +27 (0)46 6229427.
E-mail: juanita@iwr.ru.ac.za

IWA
SEPTEMBER 14 -19

The International Water Association (IWA) will host a regional conference in Cape Town with the theme: *Water as the key to sustainable development in Africa*. Simultaneously with this event, the IWA specialist group on biofilms and the specialist group on health related water microbiology will also be having their international specialist conferences.
Enquiries: Prof TE Cloete, IWSA National Committee.
Tel: (012) 420 3265
Fax: (012) 420 3266
E-mail: tecloete@postino.up.ac.za
Website: http://www.iwaconferences.co.za/

WATER MICROBIOLOGY
SEPTEMBER 14 - 19

An international symposium on health-related water microbiology will be held in Cape Town.
Enquiries: Ms Heidi Botha, Organising Committee, 2003 Cape Town symposium (HRWM), Department of Virology, University of Pretoria, Pretoria.
Tel: (012) 319 2351
Fax: (012) 325 5550
E-mail: bothah@med.up.ac.za

**THE INTERNATIONAL WATER ASSOCIATION (IWA)
IS PLEASED TO ANNOUNCE:**

INTERNATIONAL WATER CONFERENCES

**CAPE TOWN
14-19 SEPTEMBER 2003**

South Africa will host the following conferences on:

- **Water as the key to sustainable development in Africa**
- **Biofilms** (IWA Specialist group)
- **Health Related Water Microbiology** (Specialist group)

We look forward to receiving papers, posters and/or other scientific contributions to the conference, including your presence and active participation.

For more details visit: www.iwaconferences.co.za
email: tecloete@postino.up.ac.za

For handout advertising and exhibition space:
email: marian@lantic.net

SOUTHERN AFRICA & AFRICA 2004

WATER SUPPLIERS
FEBRUARY 19 - 24

The Union of African Water Suppliers (UAWS) will be holding its 12th bi-annual African congress in Accra, Ghana.
Enquiries: Mr Dennis D Mwanza, Water Utility Partnership (WUP), 05 BP 2642, Abidjan, Cote d'Ivoire.
Tel: +225 21 2408 28
Tel (direct line): +225 21 2408 13.
Cell: +225 07 0199 01
Fax: +225 21 75 8656/7

OVERSEAS 2003

URBAN WATER SUPPLY
APRIL 2 - 4

The 2nd international conference on the efficient use and management of urban water supply will take place in Tenerife, Canary Islands, Spain.
Enquiries: Efficient 2003, Consejo Insular Aguas de Tenerife, C/Leoncio Rodriguez 7, 2Bð Edificio "El Cabo" 38003 Santa Cruz de Tenerife, Espana.
Tel: +34 922 208800
Fax: +34 922 208 863
E-mail: efficientwateruse@iwatenerife 2003.org

HYDROLOGY
APRIL 7 - 10

An international conference on hydrology in the Mediterranean and semi-arid regions will be held in Montpellier, France.
Enquiries: Conference 2003, Laboratoire HydroSciences Montpellier, UMR 5569, BP 5045, 34032, Montpellier Cedex, France
Tel: +33 4 6714 9020
Fax: +33 4 67149010
E-mail: montpellier2003@msem.univ-montp2.fr
Website: http://mpl.ird.fr/montpellier2003

WATER RESOURCES
APRIL 7 - 11

An international workshop on integrated water resources management will be held in Denver, Colorado, USA.
Enquiries: US Bureau of Reclamation.
Tel: 1-303-445-2127
Fax: 1-303-445-6322
E-mail: Rprincipe@do.usbr.gov
Website: http://www.usbr.gov

PEDS 2003
APRIL 22 - 25

The first international conference on pumps, electromechanical devices and systems (PEDS) will be held in Valencia, Spain. Main topics will include: pumps and pumping stations in urban water management, pipe characteristics, materials and installation techniques, leak detection, water audit techniques, pressure surges control and urban water systems operation.
Enquiries: Dr Enrique Cabrera.
E-mail: gcabrera@gmf.upv.es
Website: http://www.iahr.upv.es

WATER & DRAINAGE
APRIL 28 - 30

This conference and exhibition which addresses the water supply, wastewater and drainage industry will be held in the Putra World Trade Centre, Kuala Lumpur, Malaysia. The theme is "Managing our Resources - the changing value of water".
Enquiries: Water & Drainage 2003 Secretariat.
E-mail: melissa@protemp.com.my
Website: http://www.water-drainage.com/

RIVER BASINS
APRIL 28 - 30

The 2nd international conference on river basin management will be held in Las Palmas, Gran Canaria, Spain.
Enquiries: Stacey Hobbs
E-mail: shobbs@wessex.ac.uk
Website: http://www.wessex.ac.uk/conferences/2003/

GROUNDWATER
MAY 2003

The third international symposium on water resources in karst and hard formations will be held in Esfahan, Iran.
Enquiries: Dr A Afrasiabian, Director of National Karst Study and Research Centre, PO Box 15875-3584, Teheran, I.R. Iran.
Tel: +98 21 7520474
Fax: +98 21 7533186.
E-mail: karstsympo2003@yahoo.com

IRRIGATION
MAY 12 - 15

The 2nd international conference on irrigation and drainage will take place in Phoenix, Arizona, USA. Theme: "Water for a sustainable world - limited supplies and expanding demand.
Enquiries: Larry Stephens
Tel: 303 628 5430
Fax: 303 628 5431
E-mail:stephens@uscid.org

AQUACULTURE
MAY 19 - 23

The annual meeting of the world aquaculture society - Aquaculture 2003 - will be held at the Bahia Convention Centre in Salvador, Brazil. Theme -" Realising the potential: Responsible aquaculture for a secure future".
Enquiries: Conference Manager. 2423 Fallbrook Place, Escondido, CA 92027, USA.
Tel: +1 760 432 4270
Fax: +1760 432 4275
E-mail: worldaqua@aol.com

AQUIFERS
MAY 28 - 30

The first international workshop on aquifer vulnerability and risk will be held in Salamanca, Gto Mexico. The aim will be to develop a multidisciplinary network forum for groups working with aquifer vulnerability and risk assessment methodologies.
Enquiries: Dr Ramiro Rodriguez.
E-mail: rrdz@tonatiuh.igeofcu.unam.mx
Website: http://www.igeofcu.unam.mx/avr03
or http://www.cotascerca.com/avr03

FOREST WASTEWATERS
JUNE 2 - 4

The 7th international symposium on forest wastewaters will be held in Seattle, USA.
Enquiries: Ms Sirpa Sandelin, Satakunta Polytechnic, Centre for Adult & Continuing Education, Tekniikantie 2, FI-28600 Pori, Finland.

Tel: +358 5050 20130
Fax: +358 26203 105
E-mail: sirpa.sandelin@tp.spt.fi

WATER QUALITY
JUNE 9 – 13

A short course on the design of water quality monitoring networks will be presented in Fort Collins, Colorado, USA.
Enquiries: Thomas G Sanders, Course Director, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523. Fax: (970) 491 7727
Tel: (970) 491 5448
E-mail: TGS@engr.Colostate.Edu
Website: http://www.engr.colostate.edu/depts/ce/

AWWA 2003
JUNE 15 - 19

The American Water Works Association will hold its annual conference and exhibition in Anaheim, California. Membership in AWWA is not a requirement for presentation.
Enquiries: AWWA, 6666 W. Quincy Ave., Denver, CO 80235
Tel: 303 794 7711
Fax: 303 794 3951
Website: http://www.awwa.org

WATER POLLUTION
JUNE 18 - 20

The 7th international conference on modelling, monitoring and prediction of water pollution will be held in Cadiz, Spain.
Enquiries: Rachel Green, Conference Secretariat, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southhampton, SO40 7AA
Tel: 44 (0) 238 029 3223
Fax: 44 (0) 238 029 2853
E-mail: rgreen@wessex.ac.uk

WASTEWATER
JUNE 23 - 25

An international conference on wastewater sludge as a resource will be held in Trondheim, Norway.
Enquiries: Prof Hallvard Odegaard, Dept of Hydraulic and Environmental Engineering, N-7034 Trondheim, NTNU.
Tel: +47 73 594759
Fax: +47 73 590 544
E-mail: hallvard.odegaard@bygg.ntnu.no

WATERSHED MANAGEMENT
JUNE 29 - JULY 3

An international conference on Watershed management for water supply systems will be held by the American Water Resources Association (AWRA) in New York City, New York, USA. Topics will be from the fields of science and technology, policy and management and education and outreach.
Enquiries: Peter E Black, Organising Chair, SUNY College of Environmental Science and Forestry, Syracuse, NY 13210 USA
Tel: 1(315) 470 6571
E-mail: pebchair@esf.edu
(or bestweb.net)

ROCK DRAINAGE
JULY 12 - 18

The 6th international conference on acid rock drainage (6th ICARD) with the theme "Application and Sustainability of Technologies" will be held in Cairns, North Queensland, Australia.
Enquiries: Ms Miriam Way, Events Manager, The AusIMM, PO Box 660, Carlton South VIC 3053 Australia
Tel: 61 3 9662 3166
Fax: 61 3 9662 3662
E-mail: miriam@ausimm.com.au

ACTIVATED SLUDGE
JULY 28 - AUGUST 1

The 14th annual short course on the methodologies and laboratory techniques to generate process control parameters for operating an activated sludge process will be held in Estes Park, Colorado.
Enquiries: Thomas G Sanders, Course Director, Department of Civil Engineering, Colorado State University, Fort Collins, CO 80523
Fax: (970) 491 7727
Tel: (970) 491 5448
E-mail: TGS@engr.Colostate.Edu
Website: http://www.engr.colostate.edu/depts/ce/

BASIN MANAGEMENT
AUGUST 17 - 22

The 7th international conference on diffuse pollution and basin management will be held in Dublin, Ireland.
Enquiries: IWA Conference Secretariat, Centre for Water Resources Research, Civil Engineering Department, University College Dublin, Earlsfort Terrace, Dublin 2, Ireland
Tel: 00 353 1 7167 499
Fax: 00 353 1 7167399
E-mail: dipcon@ucd.ie
Website: www.ucd.ie/~dipcon/dipcon.htm

BIOFILM SYSTEMS
SEPTEMBER 2003

The 5th international conference on biofilm systems will be held in Noordwijkerhout, the Netherlands.
Enquiries: Mark van Loosdrecht, TU-Delft, Julianalaan 67, 2628 BC Delft, the Netherlands.
Tel: +31 15278 1618
Fax: +31 152 78 2355
E-mail: m.c.m.vanloosdrecht@tnw.tudelft.nl

WASTEWATER PLANTS
SEPTEMBER 1 - 4

The 9th conference on the design, operation and costs of large wastewater treatment plants will take place in Prague, Czech Republic.
Enquiries: Prof Dr Jiri Wanner, Dept of Water Technology and Environmental Engineering, Prague Institute of Chemical Technology, Technicka 5, CZ-166 28 Praha 6, Czech Republic.
Tel: +420 2243 53149.
E-mail: jiri.wanner@vscht.cz

IRRIGATION
SEPTEMBER 1 - 5

The 4th international symposium on irrigation of horticulture crops will be held in Davis, California, USA.
Enquiries: Conference & Event Services, One Shields Avenue, Davis, CA 95616, USA.
Fax: (530) 752 5791
Website: http://www.cevs.ucdavis.edu