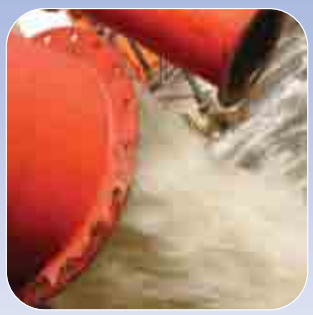
Water Research Commission

Knowledge Review 2007/08

knowledge for growth and development

Contents





vision

To be a globally recognised leader in providing innovative solutions for sustainable water management to meet the changing needs of society and of the environment.

mission

The Water Research Commission is a dynamic hub for water-centred knowledge, innovation and intellectual capital.

We provide leadership for research and development through the support of knowledge creation, transfer and application.

We engage stakeholders and partners in solving water-related problems which are critical to South Africa's sustainable development and economic growth, and are committed to promoting a better quality of life for all.

Introduction

Dr R Kfir | Chief Executive Officer |
Water Research Commission

INVESTING IN THE CREATION AND SHARING OF KNOWLEDGE

During 2007/08 the WRC continued to serve South Africa's government reporting via its Board to the Minister of Water Affairs and Forestry, its shareholder, and DWAF. Knowledge created through WRC funds strongly supports DWAF's overarching objective, i.e. water for economic growth and sustainable development. The WRC continued to support the water sector and all its relevant institutions and partners by providing them with knowledge aimed at informing their decision-making processes, improving their monitoring and assessment tools and making available a new and improved range of technologies related to water resource management and the provision of water and sanitation services. The WRC also continued to address the issue of climate change and the linked phenomena of extreme events. Research conducted by the WRC and its research partners will support the development of adaptive and mitigating strategies which will ensure the future sustainability of the country's water resources and services.

The research portfolio for 2007/08 was set on the basis of the WRC's strategic plan. The WRC continued to invest in the creation of knowledge via its four main key strategic areas (KSAs). These areas include **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management, and Water Utilisation in Agriculture**. In general, the portfolio as planned for the year under review was well received by the various stakeholders. The Institutional Review also supported the research portfolio and the KSA-based structure, with its four water-centred KSAs (as mentioned above), supported by the KSA: **Water-Centred Knowledge.** This structure continued to form the core operating framework for WRC-funded research and development (R&D) and was further consolidated during the year and became accepted generally.

Water Resource Management – Research carried out by this KSA aimed at ensuring that the water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research aimed at developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa; building appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (including an understanding of the impact on human health);providing control measures for improving the prevention, mitigation and control of pollution of water resources and supporting and improving policy reforms for promoting equitable, efficient and sustainable conservation and allocation of water resources among competing needs. During 2007/08 the WRC invested in research projects in four research thrusts in this KSA, including water resource assessment and planning; management of natural and human-induced impacts on water resources; water resource protection and water resource institutional arrangements.

Water-Linked Ecosystems – This KSA invested in the creation of knowledge aimed at enabling good environmental governance and ensuring the utilisation and sustainable management of water-linked ecosystems in our water-scarce country during a time of demographic and climate change. The research developed the understanding of the ecological processes underlying the delivery of goods and services and provided knowledge to sustainably manage, protect and utilise aquatic ecosystems. Three main research areas were addressed during 2007/08, including research on ecosystem processes, i.e. the biophysical processes, form and function of ecosystems; ecosystem management and utilisation, including issues such as the ecological reserve; and ecosystem health and rehabilitation (rivers and wetlands).

Water Use and Waste Management – This KSA focused mainly on research for the domestic, industrial and mining water sectors. The aim was to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. During the year under review, this KSA supported studies on appropriate technologies for improving the quality and quantity of our water supplies for domestic use with a focus on water supply and treatment technology serving the urban, rural, large and small systems. Research was conducted on new ways to manage and enhance hygiene and sanitation practices, and on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Infrastructure for both water supply and sanitation was included. Waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors were also addressed and innovative as well as integrated solutions to water and waste management in the industrial and mining sectors were studied. The research areas included water services – institutional and management issues; water supply and treatment technology; wastewater and effluent treatment and reuse technology; industrial and mine water management; and sanitation, health and hygiene education.

Water Utilisation in Agriculture – Research carried out in this KSA aimed at increasing household food security and improving the livelihoods of people on farming, community and regional levels through efficient and sustainable utilisation and development of water resources in agriculture. More specifically, the research focused on increased biological,

technical and economic efficiency of water use, the reduction of poverty through water-based agricultural activities, the increases in profitability of water-based farming systems and the sustainable water resource use through protection. All agricultural sub-sectors were addressed including irrigated and dry-land agriculture; woodlands and forestry; grasslands and livestock watering and aquaculture. During 2007/08, research was conducted in three main areas including water utilisation for food and fibre production; water utilisation for fuel-wood and timber production; and water for poverty reduction and wealth creation in agriculture. Research specifically addressed small-scale farming and rural communities.

Supporting research projects

During the year under review, the WRC supported 286 research projects, of which about 75% (216 projects) were active projects (ongoing and new) and about 24% (70 projects) were finalised. The active projects comprised 149 ongoing projects and 67 newly initiated projects that commenced during 2007/08. The various mechanisms of funding included both non-solicited projects, accommodating projects within the broad research strategy of each KSA, and solicited projects, where research projects are developed in accordance with clear terms of reference, aimed at solving specific problems. The WRC supported 75 solicited projects, which translates to about 35% of active projects.

The reduction in the total number of projects is directly related to the reduction of the number of ongoing projects and is a clear indication of improved project management with special reference to the deliverable framework which was introduced in recent years. In comparison with the previous year, the year under review shows a 9% decrease in the number of projects. There is an increase of 20% in new projects in comparison to the previous year. In addition, this also relates to the increase in the number of active solicited projects which increased by 12% from the previous year. These projects are often large and include a number of organisations working as a consortium. This reflects the WRC commitment to address the needs of the South African water sector where research problems are often of a complex nature which requires larger projects of a multidisciplinary nature.

Total investment in the support of knowledge creation, sharing and dissemination amounted to R99.2m. This represents an increase of 16% from the previous year (R85.5m. total investment was reported in 2006/07). This investment includes about R4.3m. for the Water Information Network (WIN-SA) and other income leveraged for research projects during the year under review. Both the investments in research projects and in research support, expressed as a percentage of total expenditure, were close to the set budgeted ratios and almost identical to that of previous years. The ratio addressing the funding of the creation of new knowledge (research projects only) is almost identical to that of the previous year, with only a 1% increase. The ratio for research support is also similar to that of the previous year, with only a 1% increase.

Leveraging income for the creation, sharing and dissemination of water-centred knowledge

During the year under review the WRC continued to leverage levy income by striving to obtain funds from other sources to support water research. During 2007/08 this drive has been highly successful. The WRC income originating from sources other than the levy for 2007/08 amounted to R13.3m. Leveraged income included funds allocated to a number of KSAs for direct support to research projects and funds provided for knowledge sharing and dissemination (e.g. WIN-SA). Leveraged income was obtained from both local and international sources, where the main source of income was due to support by various government departments for specific research and other knowledge-sharing projects. Other sources of income amount to about 15% of the total income.

BUILDING THE WATER-CENTRED KNOWLEDGE BASE – CAPACITY BUILDING

During the year under review, the WRC placed strong emphasis on building research capacity in South Africa. By increasing the number of students conducting water research, the WRC provides South Africa with a good basis for future researchers as well as a source of skilled human capital for other institutions within the water sector. In many areas of research supported by the WRC, it is evident that students who participated in earlier WRC projects are currently leading WRC-funded research projects and are serving as members of steering committees as well as reviewers of new proposals.

During the current year (2007/08) the WRC has excelled in its support to students, with special emphasis on historically disadvantaged students. Currently about 664 students are supported by WRC projects, of whom about 65% are from disadvantaged backgrounds. This is a significant increase in the number of students as well as an increase in the percentage of historically disadvantaged students as compared to previous years. This clearly indicates that the WRC's strategy to improve capacity building through its research projects continues to bear fruit. Of all the institutions supporting students, universities are clearly leading with 452 students, of whom 286 or 63% of students originate from historically disadvantaged backgrounds. Although all universities support students, the University of KwaZulu-Natal exceeded all with about 94 students, followed by the University of Cape Town with 68 students, 48 students at the University of Stellenbosch and 43 at the University of the Western Cape. Science Councils supported more than 50 students, with the CSIR supporting 37 students, of whom 62% are from historically disadvantaged backgrounds. The large water boards, including Rand Water and Umgeni Water, also indicated a large number of students totalling 20 with 60% originating from historically disadvantaged backgrounds. There is also a clear pattern of an increased number of students involved in projects led by consultant groups. Many consulting firms indicated the involvement of about 10 students. The increase in the number of students in non-academic institutions is encouraging as these students represent 'on the job' continuous development and/or new skilled human capital for the sector. The increase in the number of students is also a result of the WRC strategy of building research networks and research consortia.

Institution	Number of disadvantaged students	Total number of students
African Water Institute (AWI)	1	1
Anchor Consultancy (linked to UCT)	13	13
ARC	2	4
AWARD	1	1
Cape Peninsula University of Technology	6	9
Central University of Technology	1	1
Chris Swartz Water Utilization Engineers	16	16
Conningarth Economists	2	4
Conward Consulting	3	4
Council for Geoscience	2	3
CSIR	23	37
Digby Wells and Associates	2	4
Durban University of Technology	2	2
Duzi-uMngeni Conservation Trust	1	1
Emanti Management (Pty) Ltd	3	3
ERWAT	1	2
GEOSS	1	3
Golder Associates Africa (Pty) Ltd	7	7
Groundwater Africa	1	1
HSRC	2	2
Jeffares & Green Consulting Engineers	2	3
Nelson Mandela Metropolitan University	5	20
Nemai Consulting	2	2
Ninham Shand	0	2
Palmer Development Group	2	2
Partners in Development cc	6	6
Pegram and Associates	4	5
Proxa (Pty) Ltd	1	1
Pulles, Howard and de Lange (now with Golder)	7	12
Rand Water	3	8
Rhodes University	7	14
Rural Integrated Eng	7	7
SA Institute for Aquatic Biodiversity	2	7
SASRI	3	4
SAWS	2	3
Sigma Beta	0	1
Source Strategic Focus	2	3
SRK	6	8
Sustainable Environmental Technologies	1	1
TBR Project	1	1
Tshwane University of Technology	11	11
The Impact Free Water Group	4	5
Umgeni Water	10	12
Umhlaba Consulting	1	1
University of Cape Town	45	68
University of Fort Hare	18	19
University of Johannesburg	6	7
University of KwaZulu-Natal	50	94
University of Limpopo	3	4
University of Pretoria	30	45
University of Stellenbosch	28	48
University of the Free State	14	27
University of the North West	8	16
University of the Western Cape	32	43
University of the Witwatersrand	8	18
University of Venda	12	17
Zitholele Consulting (Pty) Ltd	1	1
	434	**664**

Students supported by the WRC attended and delivered presentations on WRC-related projects within South Africa and also beyond its borders. Examples include, Geoff du Toit from UCT, and Valentina Parco, from Palermo, Italy, who presented a joint paper on the work of their respective Doctorate and Masters degrees at the IWA Young Professionals Conference on Membranes for Water and Wastewater Treatment. The event was held between 4 and 6 June in Berlin. These innovative young students worked in the UCT Water Research Group (WRG) laboratories under the guidance of Professor George Ekama and Associate Professor Mark Wentzel, on a WRC-funded project to better understand the impact of micro-filtration membranes on the performance of biological nutrient removal (BNR) systems. The solid-liquid separation step is crucial to the effectiveness of the BNR process and membranes, when used correctly, can reliably ensure this step in the treatment process. Marcelle Marchand, a Ph.D. student in the Department of Zoology at the University of Pretoria, received a Young Scientist Award (YSA) for her poster presentation at the 17th annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC) in Porto, Portugal in 2007. The award is presented annually and is intended to honour individual prominent performance in scientific work of a junior scientist under the age of 30. Marcelle will receive the award at the Opening Ceremony at the 18th annual SETAC meeting to be held in Warsaw, Poland during 2008. Marcelle's project was achieved through WRC-funded research.

One of the important areas requiring the building of competence is that of local government. The WRC serves as the implementing agent for DWAF with regard to WIN-SA. The WIN-SA sector initiative is growing in strength. WIN-SA is aimed at knowledge sharing and capacity building for local government. WIN-SA's *Water Services Councillor Induction* (instructional DVD) has 'got the whole country talking'. It is a very useful and concise tool aimed at capacitating local government: it captures essential issues, enables councillors to see the real picture and to hear from other councillors. The growth of the WIN-SA *Lessons Series* is highly appreciated by local government and other stakeholders. Nine lessons have been completed covering various themes which focus on improved service delivery by local government. The WIN-SA *Fieldnote Series* was launched this year. This series captures discrete experiences by local government in a two-page document that is easily accessible. The new look WIN-SA website has recently been launched. It seeks to provide easier navigation and access to information. WIN-SA recently conducted a learning journey for 12 officials from the North West and the Northern Cape provinces, to learn more on operations and maintenance of infrastructure. This initiative was highly appreciated by local government in both provinces.

Another key capacity-building area in the development of competencies and capacity regarding water resource management is FETWater. The WRC continues to co-lead the activities of the **Framework for Education and Training in Water (FETWater)**, a joint UNESCO, Belgian and South African programme aimed at building improved capacity in integrated water resource management. During the year under review, the WRC assumed the position of implementing agent for Phase II of the programme.

Building capacity in Africa

The WRC's capacity-building activities continue to address both support for Africa and participation in global initiatives aimed at building capacity: Some examples include:

- NEPAD – network of centres of excellence for water research in Africa. This is an ongoing dedicated activity, where the WRC coordinated and led the process of establishing the network in cooperation with the French Institute for Development Research (IRD). During the year under review a framework was developed to determine criteria to select those organisations that would act as centres of excellence. The process of selection in currently ongoing.
- Water Research Fund of Southern Africa (WARFSA). The WRC has been involved in this research-capacity programme for a number of years. Currently one staff member serves as a Board member of WARFSA. WARFSA was established with the purpose of building research capacity among regional institutions and individuals as well as promoting the utilisation of research results in the planning and management of water resources in the sub-region. The WRC coordinated the logistics of the WARFSA Board meetings.
- Streams-Africa. Another example is the WRC's role in *Streams of Knowledge*, a network of capacity-building organisations, focused on water and sanitation, with most members being from various parts of Africa. The network is led by a staff member of the WRC. In recent months, in cooperation with WIN-SA, a number of African resource centres are developing a plan to build *Stream-Africa*, which will specifically support capacity building in water and sanitation in Africa with an initial focus on Southern Africa.

INNOVATIONS AND KNOWLEDGE APPLICATION

The WRC continues to support the development of new applied knowledge and water-related **innovation**. While the WRC supports many innovations which are considered to be advantageous to the public and are readily available for use, some technologies, processes and products require commercial involvement in order to make them publicly available. In recent years the WRC supported the **commercialisation** of such innovations where applicable. However, the process has proved to be complex (requiring dedicated specialist support) and to have long-term prospects (often several years are required). In this connection, although a high percentage of the patent portfolio of the WRC is licensed out, the WRC continues in its effort to earn income from its licensed IP. In addition, with the improved capabilities of certain academic institutions to manage IP, the WRC has opted, in certain cases, to sign benefit-sharing agreements and allow these institutions to take the commercialisation process forward. An example is the **Olive Wastewater Treatment Technology** which was assigned to the University of Cape Town (UCT) and a benefit-sharing agreement was signed.

Currently, the WRC has licence agreements with reputable South African and international companies. These include one innovation earning royalties, i.e. **The Secondary Metabolites**, a cluster of 13 patents, which is currently licensed to Synexa-Life Sciences and the WRC has been receiving royalties since 2006. Two other licensed innovations including the **BioSURE™ Process**, a cluster of 36 patents, which is licensed to ERWAT and the **Ambient Temperature Ferrite Process (ATFP)** for removing iron from acid mine drainage, which is currently licensed to Environmental Technology Agencies (ETA) are currently undergoing further development. Such development is often required to allow the technology to function at a large scale. During the year under review another innovation was licensed out. This is an invention that will allow the provision of clean water at a small scale and could effectively provide for drinking water for small rural communities. The **Filtration Membrane Technology (CUF)**, a cluster of 5 patents, was licensed to Ikusasa Chemicals in January 2008.

The filing of 5 patent applications (filed during 2006/07) is at different stages of prosecution and licensing negotiations. These patents include:

- Biosensor
- Method of detecting the presence of micro-organisms in a solution
- Passive sampler
- Application for fly ash and its derivatives
- Synthesis of zeolites.

In January 2008 one Patent Corporation Treaty (PCT) patent application entitled 'Treatment of Wastewater using Dual-Stage Membrane Bioreactor' was filed. The invention relates to a wastewater treatment process for removing undesired impurities from effluent feed. The process includes the steps of providing a discrete acclimation bioreactor system for developing a desired micro-organism inoculum, with the system being in selectively interruptible fluid flow connection with a discrete effluent hydrolysis system. This allows the flow of desired micro-organisms from the

bioreactor system to the effluent hydrolysis system to be regulated independently from the effluent feed flow through the hydrolysis system, leading to greater flow-through and system efficiencies.

The WRC is investigating various modalities for marketing its inventions, and is currently negotiating the support of a reputable South African technology broker company in this regard. The WRC is also developing a technology transfer website (to feature within the WRC website) that would be used to promote WRC inventions.

Innovations

As indicated above, the WRC supports many innovations that do not require a commercial route for their transfer and applications. Examples of such innovative methods and tools include:

- The Ambic protocol for recovery and detection of *Ascaris* ova – an improved method for recovery of *Ascaris* ova was developed through a WRC study. The method allows for the removal of interference due to soil particles and improves recovery by up to 77% yield.
- Water services barometer tool – general public's knowledge / awareness / understanding / behaviour regarding key water services messages can serve as an indicator of the 'state of community consultation'. The barometer was constructed in order to give a 'reading' of the current state of knowledge and awareness amongst the South African public regarding key water services knowledge areas. The barometer instrument can be applied to assess any community consultation process and can be used as a tool to determine whether the target audience was reached and whether the money was well spent.
- The twin-channel vertical slot fish-way – is a new concept internationally. It has revolutionised fish-way design and will reduce the cost substantially from existing designs, carrying a wide range of fish species and sizes. It can be incorporated in the back of a Crump Weir, which is the commonly used design of a gauging weir on the larger South African rivers.

LEADING WATER-CENTRED KNOWLEDGE

The WRC serves South Africa as its water-centred knowledge hub. As such the WRC has to provide leadership and strategic direction regarding knowledge creation, sharing and dissemination. The standing of the organisation locally, in Africa and globally is therefore of utmost importance. During the year under review the WRC improved its standing locally and led and coordinated many local strategic initiatives. In addition, the WRC excelled in its drives to link with and support Africa and in linking South Africa to global knowledge, i.e. with the aim of excelling in leading water-centred knowledge in South Africa.

LOOKING AHEAD

Effectively looking ahead requires an understanding of where we come from and what has been achieved to date. It also calls for understanding the current and future of the WRC environment and the needs of South Africa. In 2002 the WRC took a strategic decision to transform the organisation into a dynamic hub for water-centred knowledge, addressing South Africa's research needs and supporting the dissemination and application of the created knowledge. This transformation called for fundamental changes that aimed to make the organisation highly relevant, effective and efficient. It required the bold step of streamlining its business, and therefore 18 research fields were narrowed down to 5 KSAs. It also required the need for integrating mechanisms and understanding the impact of the research. The WRC identified the impact areas of the economy, society, health and the environment as key to its research portfolio. Collectively, these areas support the objective of water serving as a driver for economic growth and sustainable development. While organising the WRC along four key areas related to water issues from water resource management to its effective uses, the WRC has built strong support for knowledge sharing, dissemination and application through its **Water-Centred Knowledge** KSA. It has also invested in enhancing its financial and legal functions. Functioning as South Africa's dynamic and credible water knowledge hub required the WRC to be close to its shareholder and key stakeholder, the Minister and the Department of Water Affairs and Forestry and to actively reach out to the water sector, related sectors and the community at large.

Transformation of the WRC was not only internally focused. The WRC targeted research areas and provided knowledge that, if appropriately utilised, could effectively improve the quality of life of all South Africans, providing them with a reliable and safe water supply and sanitation and contributing to future economic growth. Transformation of the water sector also required skills and competencies. The WRC has been supporting historically disadvantaged students with the aim of not only building a new generation of researchers, but also providing new skilled capacity to the sector.

While building and continuing its service to South Africa, the WRC realises the importance of partnerships and building strong networks locally, globally and, especially, in Africa. In recent years the WRC initiated a strategic drive to strategically support a number of initiatives in building water research capacity in Africa.

As reported during the financial year, the WRC continued to serve South Africa as its dynamic water-centred knowledge hub. Building capacity, creating new knowledge and improving its mechanisms regarding knowledge dissemination were matters of priority. In future years the WRC aims to further build on what has been achieved, adhering to its mandate of providing the country with a knowledge framework that will ensure that the country has safe drinking water and sanitation for all and that the quantity and quality of water available for various water uses will promote a healthy environment and sustainable economic growth. The WRC will continue to support its shareholder and DWAF in realising the objective of water for Sustainable Growth and Development, while providing the knowledge required for sustainable infrastructure for water and sanitation services; effective water management policies; and systems and adaptive and mitigating strategies to face the challenges of climate change.

KSA 1: Water Resource Management

Ms Eiman Karar | Director |
Water Research Commission

SCOPE

The KSA will take account of pertinent developments taking place in the implementation of the National Water Act of 1998. As such, the focus will continue to be guided by the Bill of Rights, the Constitution of South Africa section 27 (1)(b) 'everyone has the right to have access to sufficient water' and by the principles and objectives of the said Act (NWA). The primary principle of the Act is that water resources should be managed to achieve optimum long-term social and economic benefits for all. This implies maintaining an optimum balance between protection of the environment and efficient water utilisation. The supporting principles are:

- The basic human needs of present and future generations
- The need to protect water resources
- The need to share some water resources with other countries
- The need to promote social and economic development through the use of water
- The need to establish suitable institutions.

This KSA supports the implementation of the NWA by:

- Developing tools and technologies for overall water resource management
- Supporting decision making by reviewing existing policies and strategies
- Providing quick responses to immediate and specific research questions in support of national initiatives
- Providing platforms for debate
- Building capacity in project teams and steering committees
- Disseminating resultant information as widely as possible
- Encouraging partnerships through joint projects with key stakeholders.

In recent years, the research focus in this KSA has been shifting from supporting policy making to providing guidance for policy implementation and the development of policy instruments. The challenge for research in this KSA is to provide the necessary information systems, guidelines, decision-support systems, prediction tools and technologies/ methodologies that support planning, development and protection of water resources. As the decentralisation of the management of water resources is in its infancy, information systems supporting local decision making become critical. The NWA places emphasis on stakeholder participation in water resource management which forms a blend between the decentralisation and democratisation for decision making. The role of local government in the management of water resources needs to be better understood, as well as its responsibilities and inter-relatedness. Ground-breaking research on pricing, value chain and service delivery in the water resource management arena is required for financial sustainability at a national level. Research in this KSA will highlight the emerging trends and reflections from the implementation of the NWA to date: what has worked and what has not. This can be achieved by exploring scenarios and by making future projections for policy review and bench-marking. Furthermore, a comprehensive and integrated monitoring and regulatory framework must be in place in order to achieve decentralisation and delegation of authority to local water management institutions. Compliance and enforcement of provisions in the Act exacerbate an already stretched sector whose absorptive capacity for research findings is limited. Internationally shared water remains a strategic focus with particular research needs, and with emphasis on defining the suitable pathways for engaging local management institutions without compromising the sovereignty rule.

Other key issues informing the research addressed by this KSA are issues related to climate change. Climate change and hydroclimatic variability can have serious implications on the triple bottom line (environmental sustainability, economic growth and social justice) and on sustainable development. The conjunctive use of surface water and groundwater should filter down to addressing seamless research needs for both social and economic development.

OBJECTIVES

The primary objective of research in this KSA is to ensure that the water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The secondary aims have been streamlined from previous business plans to reflect the needs analysis process. Thus, the revised aims to support the primary objective are to:

- Develop a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (including the understanding of the impact on human health)
- Provide control measures for improving the prevention, mitigation and control of pollution of water resources
- Support and improve policy reforms for promoting equitable, efficient and sustainable conservation and allocation of water resources among competing needs.

In view of the above revised aims, the thrusts have been realigned as follows:

Thrust 1: Water Resource Assessment and Planning
Thrust 2: Management of Natural and Human-Induced Impacts on Water Resources
Thrust 3: Water Resource Protection
Thrust 4: Water Resource Institutional Arrangements

THRUSTS AND PROGRAMMES

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Scope: This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning. The thrust will promote better understanding of the variability of the quantity and quality of water available for use and further development in South Africa. Recent changes in national water resources infrastructure management, the awareness of the poor state of water resources infrastructure and increased knowledge of water resource planning needs are expected to receive attention, through the support of competent and sustainable solutions. Sound water resource assessment and planning can only be achieved with reasonably accurate and consistently recorded and processed data and information. The thrust will support the implementation and use of a national water resource information system through:

- Catchment data and information systems
- Surface water / groundwater hydrology
- Water resource planning
- Water resource development
- Climate change and hydro-climatic variability
- Water resource quality management.

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Scope: Research in this thrust focuses on developing appropriate understanding, tools and strategies for managing the impacts of climate variability and change as well as human interventions on the hydrological cycle and related water resources, with the aim of supporting the development of policy responses, at regional, national or catchment scale, to existing and emerging problems. This includes development of systems (e.g. river flow and inundation forecast models, drought-impact monitoring systems) for the management of floods and droughts:

- Developing mitigation and adaptive measures for global climate change
- Human-induced effects
- Integrated flood and drought management.

THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow reduction processes as well as other physical processes such as sediment accumulation through:

- Protection and management of surface water and groundwater quality
- Urban and rural water resource management
- Integrated river flow and catchment hydraulics.

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders based on catchment and water management area boundaries. The marked shift from central management of resources to more localised scale is critical to the main founding concepts of integrated water resource management (IWRM). The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust supports research on tools and methodologies for IWRM decision support which aims to provide strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures for implementing IWRM through:

- Institutional governance and reforms
- Compliance and enforcement
- Pricing and financing of IWRM
- Transboundary water resources
- Future scenarios.

RESEARCH PORTFOLIO FOR 2007/08

The knowledge base generated in this KSA can assist South Africa in moving away from a sectoral approach to water resource management to more integrated approaches that promote coordinated development of water, land and related resources in order to achieve social equity and economic growth. The research results will continue to contribute to the development of a skilled and competent pool of experts who can support the implementation of national water policy and also provide leadership and advice to the sector at regional and global levels. The current emphasis of the research portfolio is on supporting the implementation of the National Water Resource Strategy through the following broad ways:

- Empirical scientific understanding of the hydrological cycle and information systems to enhance planning and the equitable allocation of water resources
- Promoting research that deals with integrating the studies on surface water and groundwater resource assessments and protection
- Supporting policy decisions by researching options and pathways for improved management of water resources
- Applying research findings and action-oriented research to enhance water resource research uptake.

During the past funding cycle the research community has been given an opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. This year's plan is informed by the recent external Institutional Review of the WRC and the needs expressed by the Minister of Water Affairs and Forestry as well as other consultations with government and various institutions and individuals. During 2007/08, the opportunity will once again be given to the research community to respond to the water resource management challenges through both the solicited and non-solicited proposal streams of funding. Continued consultation with stakeholders at local and regional levels is of vital importance to identify future research needs and priorities.

BUDGET FOR 2007/08

The approved funding of the research portfolio for 2007/08 leads to a committed funding budget of R 28 424 701. The focus of this portfolio will continue along the current trends.

CORE STRATEGY

Strategic context

Nothing is more fundamental to life than water. Not only is water a basic need, but adequate safe water underpins the nation's health, economy, security, and ecology. The strategic challenge for the future is to ensure adequate quantity and quality of water to meet human and ecological needs in the face of growing competition among domestic, industrial, commercial, agricultural, and environmental uses. To address water resource challenges which are likely to emerge in the next 10 to 15 years, decision makers at all levels of government will need to make informed choices among often conflicting and uncertain alternative actions. These choices are best made with the full benefit of research and analysis. It is therefore of great importance that the nation will continue to invest not only in applied research, but also in fundamental research that will form the basis for national implementation of water sector projects. The management of water resources continues to be of high priority in South Africa. At a national level the recent momentum towards establishing economic growth and development as the main government driver has seen different sectors including the water sector articulating their roles in economic growth and development. In the water sector this is reflected in the DWAF strategic plan for the year 2008/09 where the main objective for water resource management is set to ensure that water resources are allocated for the promotion of social and economic development. In the KSA, research has already started and will continue to address the research issues that will contribute to this government driver of Water for Economic Growth and Development (W4EGD). The KSA's research will also continue to contribute to previously supported ongoing research issues affecting all KSA stakeholders.

The KSA will place special emphasis in the following areas as well as strengthening research that addresses issues in these areas:

- The support of institutional reforms; the water law compendium which consists of some 350 water-related court cases that have been compiled from 1912 to 1998 has been a project targeted at improving the DWAF programmes on reallocation reform (WAR) imperatives which are part of the initiative of W4EGD. The compendium of water-related court cases is an instrument that is targeted at supporting water use verification for various purposes such as the water allocation reform.
- Water resource accounting is expected to benefit from improvements in the accuracy and detail of measurements and how these are interpreted in water resource simulations and other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes can only suffice if real, reliable data are available at reasonable spatial and temporal resolutions for verifications. The KSA has invested vastly in enhancing the estimates for quantifying water use and water availability. This year, the KSA also plans to contribute to the streamlining and integration of existing water resource information systems. Research that seeks to provide appropriate platforms for Catchment Management Agencies (CMAs) to collect, capture, process and utilise data in support of the national information systems will be supported through the KSA's research.
- The imminent dangers posed by degraded water resource infrastructure will be investigated and solutions developed to ensure that the existing and new programmes on infrastructure reconstruction and maintenance at national level are comprehensive.
- The deteriorating quality of water resources including water in some of the major rivers, dams and aquifers has continued to threaten the efficient and sustainable supply of reliable water to various sectors. Previous research has identified a number of water quality challenges. The KSA will seek to support research that addresses the challenges surrounding the provision of suitable and sustainable solutions for addressing water quality issues at the resource level.
- The evidence of global climate change, largely as a result of human activities, has now been documented. There is a growing consensus among global climate model projections regarding the nature and extent of the change. The main climate change consequences which are related to water resources have been identified as increases in temperature, shifts in precipitation patterns, increased frequency and intensity of floods and drought events, and, sea-level rises.
- The KSA has initiated a comprehensive research programme on climate-change impacts on water resources with a view to gaining insight into the magnitude of the impacts and the consequential adaptation needs in the sector. Subsequently, the first steps to incorporate research on vulnerability, mitigation and adaptation have already been taken. The success of this research relies on the outcomes of considerable prior investment by the WRC in water-related climate, atmosphere and ocean-atmosphere research, as well as hydrological modelling research, done over a period of more than15 years. The KSA will seek to drive further research on climate change to deal with regionalisation of climate change knowledge as well as improving the modelling processes to account for conditions that are consistent with the Southern African region.

In addressing existing and new research issues, the KSA will also attempt to deal with questions where solutions are pending:

- Can the reallocation reform (WAR) imperative satisfy the constitutional rights for clean water to all and meet the country's economic growth target of 6% per year?
- Will the rainfall-monitoring networks of 1 station in every 450 km² instead of every 25 km² provide adequate data to generate competent solutions for decision making that will satisfy the water quality and quantity needs of people, economy and the environment?
- What will the impact of climate change be on the people, economy and our society? How will the negative impacts be forecast, mitigated and reduced?

Thus, in line with WRC aims, this KSA aims at providing the country with applied knowledge and water-related innovation, by translating needs into research ideas and, in turn, by transferring research results and disseminating knowledge and new technology-based products and processes to end-users.

Needs analysis

The working approach for setting and overseeing the water resource research agenda is based on the following principles:

- An effective alliance with and active participation of water resource research stakeholders
- A systematic, strategic, and balanced agenda of both core and problem-driven research priorities set to meet short- and long-term needs
- The national water resource research effort should be coordinated to reduce needless duplication and to ensure that gaps do not occur
- Research should be multidisciplinary and interdisciplinary
- Research should be proactive and anticipate the nation's water needs and the environmental impacts of management options
- Research should be accountable to the public to assure that the water resource research investment has been appropriately utilised to meet the nation's needs.

In the current situation where demand for water increases, the impact of climate changes intensifies and storage sites reach capacity, South Africa is looking to new strategies that reduce demand, increase efficiency, provide for reuse of wastewater and allow for water trading. The knowledge emanating from research undertaken by this KSA aims to inform the decision process regarding where and how to best invest in these options and providing enabling technologies.

The methodologies followed in this needs analysis process are varied and include:

- Stakeholder workshops
- Documents, e.g. National Water Resource Strategy
- Focal group and individual interviews
- Interpretation and reinterpretation of research outcomes
- International/regional forums
- Strategic studies.

Some of the pertinent issues related to the development of the research portfolio are:

Managing risks

Water related hazards, such as floods, droughts, tropical storms, erosion and various kinds of pollution should be factored into any integrated approach to water resource management and policy. Although it is the world's poor who suffer the most when exposed to such dangers, everyone's security is at stake. One way to minimise risk is to develop more capacity in the monitoring and forecasting of extreme events. With this information, appropriate early warning systems and infrastructure can be installed, and new planning strategies devised. It is also necessary to ensure that climate variability and change have their place in the total picture.

Sharing water resources

Competition over scarce or poorly allocated resources can lead to tension and insecurity. Therefore decision makers, communities, governments and regions must strive to develop policies that allow for sharing among all stakeholders. Many different interests are at stake and equitable solutions must be found: between cities and rural areas, rich and poor, arid lands and wet lands, public and private, infrastructure and natural environments; mainstream and marginal groups, local stakeholders and centralised authorities. At the regional and international level, many river basin and aquifer authorities are developing integrated approaches that stress cooperation of the shared resource.

Valuing water

This whole question is among the most controversial of all the challenges identified in the Ministerial Declaration emerging from the Second World Water Forum in The Hague. In many societies the whole notion of putting a price tag on something as intrinsically valuable as water is unacceptable. Yet services must be paid for. There is also much disagreement about how to balance the costs of provision and wastewater treatment with the goal of equity and finding ways to meet the needs of poor and vulnerable populations. Creative new partnerships between the public and private sectors should be developed, along with accounting and taxation systems that take full account of environmental and social factors.

Ensuring the knowledge base

This target takes account of the whole range of technical and non-technical information and knowledge, and seeks ways for all societies to benefit from their development, exchange and dissemination. National authorities and resource managers need sound scientific data on which to base their projections and decision making. Stakeholders need access to other kinds of information and educational opportunities if they are to understand and participate in the process as responsible citizens. With the development of modern telecommunications and the global marketplace, it is more than ever necessary to ensure that every community and country plays a role in building a more sustainable future.

Governing water wisely

This challenge area is particularly complex and sensitive. It moves the debate about sustainability beyond water management issues and into processes of political, social and institutional change. Many countries agree that good governance means allowing every sector of society to participate in the decision-making process and that the interests of all stakeholders should be taken into account. However, mechanisms for doing so are not always in place, even if decentralisation and the increasing involvement of civil society are worldwide trends. International cooperation and assistance may play a crucial role – particularly in developing countries – by helping to strengthen institutional capacity.

Research needs/issues

- Support the national information systems on water resources improving the available water resource information, better management of information and enhanced information dissemination to stakeholders, especially CMAs
- Integration of surface and groundwater assessments, explorations, planning and management
- National infrastructure development and management needs to meet the national growth target of 6% of gross domestic product (GDP) per year
- Impacts of climate change on people, the economy and the environment
- Adequate forecasting for flood management and disaster mitigation and preparedness
- Water quality control, mitigation measures in support of municipalities
- Evaluation and mitigation of the health impacts from human activities on surface and groundwater
- Groundwater contamination impact on communities relying on them for drinking
- Challenges for sustainability of urban systems
- Institutional arrangements for regional water resource development to meet the MDGs
- Decision support systems for CMAs
- Alignment of catchment management strategies, local economic development plans, IDPs, etc.
- Water use charges and the sustainability of water management institutions
- Benefit sharing in the management of transboundary waters.

The National Water Resource Strategy (NWRS) is a guiding document defining research requirements in this KSA. The NWRS is required by the NWA. The NWRS provides information about ways in which water resources will be managed, including the institutions to be established. It must also provide quantitative information about the present and future availability of and requirements for water in South Africa. This must be done for each of the water management areas, and propose interventions by which the two may be balanced ('reconciled'). This Strategy must also quantify the proportion of available water in each water management area which falls under the direct control of the Minister in terms of her or his national responsibilities. Research cannot provide management and immediate policy decisions. These have to be made on the basis of available information. However, the NWRS requires better information and improved information analysis tools that will allow detailed examination and evaluation of the consequences of the various policy and management options. This KSA will support the implementation of the NWRS in the following broad ways:

- Through integrated water resource assessment (developing knowledge of the different components of the resource in terms of quantity and quality and its condition in relation to reference conditions)
- By developing and refining tools and methods to support implementation of RDMs and SDCs
- By providing greater understanding of threatening processes to water resources such as global climate change, water resource degradation, over-commitment of the resource, and impacts of land use and water storage and diversion on the water resource
- By providing tools for the assessment of policy and management options (such as re-allocation of water between users, modelling, decision-support systems, and predictive tools)
- By providing data and tools for assessment of the progress of resource management programmes, and their successful refinement.

While providing research support to implement the NWA is crucial to the KSA's business, this KSA needs to support water resource management actions at global, regional and local level.

The latest *World Development Report 2006* describes the main priority water resource issues as follows:

- 'The world is not running out of water, but many millions of its most vulnerable people live in areas subject to mounting water stress.
- Some 1.4 billion people live in river basins in which water use exceeds recharge rates.
- The symptoms of overuse are disturbingly clear; rivers are drying up; groundwater tables are falling and water-based ecosystems are being rapidly degraded.
- Far more also needs to be done in the face of the threats to human development posed by climate change. This is not a future threat; global warming is already happening and it has the potential in many countries to roll back human development gains achieved over generations.
- Reduced water supplies in areas already marked by chronic water stress, more extreme weather patterns and the melting of glaciers are part of the looming challenge.
- The competition over water will intensify in the decades ahead. Population growth, urbanisation, industrial development and the needs of agriculture are driving up the demand for a finite resource.
- Meanwhile, the recognition is growing that the needs of the environment must be factored in to future water use patterns.
- Two obvious changes emerge: as national competition for water intensifies, people with the weakest right, small farmers and women among them, will see their entitlements to water eroded by more powerful constituencies.
- Second, water is the ultimate fugitive resource, traversing borders through rivers, lakes and aquifers, a fact that points to the potential for cross-border tensions in water-stressed regions. Both dangers can be addressed and averted through public policies and international cooperation.'

It is clear that the outcomes of the *Human Development Report* reinforce the locally identified issues presented above. These outcomes will also assist in identifying future research projects and programmes (including priority-setting). The KSA aims to continue to be pro-active and responsive to the

water resource management needs in South Africa.

Overview of technological trends

Research on water resource management, especially water resource assessment studies, has been characterised by the general trend towards improving the levels of detail and accuracy in water resource observations and modelling techniques. A number of projects have been initiated to address knowledge gaps in water resource processes and how these can be simulated in areas that are deficient in data and information.

Some current and potential research projects can identify technological advancements in the field of water resource management as a whole. Some of the areas that have been locally and internationally developed recently include the following:

Isotope hydrology has evolved into a multidisciplinary field. As new approaches are developed, new applications and tools are being added to the isotope toolbox. For example:

- Boron isotopes can now be used to identify traces of sewage pollution in groundwater.
- Chlorine isotopes can supply information about the origin of the salinity and the complexities of flow in large, slow moving groundwater systems. They can estimate the age of water and may indicate the size of a reservoir.
- Methods are now further refined for the measurement of isotopes like krypton-85 and helium-3 for determining the age of young water and the origins of fluids.
- Traces of now-banned chemical species such as freons can be employed as environmental tracers of surface pollutants in shallow groundwater.

Among the key challenges in future isotope applications are:

- Developing approaches to address the water problems of mega-cities
- Responding to the complex and deepening crisis of environmental pollution
- Contributing to understanding global climatic change
- Advancing professional sophistication in the practical application of isotope techniques
- Raising awareness of the role of isotope techniques in water resource management and geothermal energy resources.

Nanotechnology

The use of nanotechnology could play a large role in averting the potential future water crisis. But hoping that the 'magic' of nanotechnology will solve all water problems is naive – the basic problems of accessibility to technologies, affordability, and fair distribution still need to be solved.

Nanotechnology can provide important opportunities for the South African water resources:

- Detection of chemical and biological substances: Metals (e.g. cadmium, copper, lead, mercury, nickel, zinc); nutrients (e.g. phosphate, ammonia, nitrate, nitrite); cyanide; organics; algae (e.g. cyanobacterial toxins); viruses; bacteria; parasites; antibiotics; biological agents; etc.
- Decontamination of the above listed substances. For example, nanoparticles of gold coated with palladium are very effective catalysts for removing TCE from groundwater – 2 200 times better than palladium alone and, photocatalytic nano-materials allow ultraviolet light to destroy pesticides, industrial solvents and germs.
- Purification and filtration of water for drinking purposes, such as through nano-scale membranes or using nano-scale polymer 'brushes' coated with molecules that can capture and remove poisonous metals, proteins and germs.
- Desalination to remove dissolved salts from seawater, brackish water and wastewater.

Nanotechnology can be applied to instrumentation that will have the following attributes: Rapid response time, real-time measurements, high sample throughput, portability, for on-site analysis, multi-parameter, simple design, easy to use, low detection levels and large working range. Interest is rapidly increasing for the use and application of nanotechnology within the water industry.

Remote sensing

Data monitoring using remote sensing is undergoing a revolution in terms of technical monitoring capabilities through the advances in spatial and spectral resolution of new sensors. The continuing improvements to the analysis are also expanding the level of detail that can be extracted from imagery. One of our research projects is now applying hyperspectral imagery to accurately estimate evapotranspiration, plant water content, water stress and plant- or soil-water availability. Unlike low spectral resolution imagery which covers only selected regions of the electromagnetic spectrum, thus giving more generalised products, high spectral resolution imagery covers a wide region of the electromagnetic spectrum (approximately 400 to 2 500 nm). This gives more spectral bands with finer bandwidths (generally less than 10 nm). The finer spectral resolution allows for detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

Satellite radar tools and applications

Wider availability and use of satellite radar in water use and evapotranspiration monitoring. Our research has continued to improve and investigate new techniques for improving measurements and estimates of evapotranspiration and other variables in the water balance. Most of our users are, however, still stuck in the use of outdated and less reliable sources of information such as open water evaporation data. Our research on evapotranspiration is now looking at how the knowledge gained can be incorporated in some of the commonly used water management tools. Water legislation and management guidelines are clearly showing that spatial processes such as those in water catchments and in land-use management practices will be driven by remotely sensed data in the future. In July 2006 the South African cabinet approved the establishment of South Africa's first space agency, an initiative that heralds the wider development of many local and new research activities around satellite development and satellite data applications.

Scenario building as a tool in water management

Scenarios are a way of developing alternative futures based on different combinations of assumptions, facts and trends, and area where more understanding is needed for your particular scenario project. They are called 'scenarios' because they are like 'scenes' in the theatre – a series of differing views or presentations of the same general topic. Once several scenarios are produced at the same time, one can better understand the available options or possibilities for informed decision making in the management of water resources.

Key stakeholders

The major stakeholders are the following 5 groups as in last year's Knowledge Review:

- The Minister of the Department of Water Affairs and Forestry as the shareholder
- Government departments representing a major group that has a large stake in the research conducted, especially DWAF, which represents the water resource managers and planners, i.e. all those entrusted with developing and allocating water resources to meet the needs of the environment and various users
- Other departments such as the Department of Minerals and Energy, the Department of Science and Technology, the Department of Provincial and Local Government, the National Department of Agriculture, the Department of Health, the Department of Education, the Department of Environmental Affairs and Tourism and the Portfolio Committee on Water represent the other stakeholder group
- Major water users including farmers, mines, industries, water service providers and civil society
- South Africa shares many rivers with its neighbouring countries, therefore, the governments and major water-user groups from these countries constitute the 5th group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.

The research conducted within this KSA contributes to better water resource management for the benefit of all stakeholders and role-players.

Other stakeholders

Most of the research supported and funded by this KSA is conducted by universities, science councils and consulting firms. These role-players either contribute to the execution of the research and/or represent the private research institutions such as the petroleum industry, paper industry, energy, sugarcane, forestry and the information technology industry, such as Siemens.

STRATEGIC INITIATIVES

National initiatives

Staff members continue to undertake various leadership positions (many are ongoing or set for a term of a number of years). These positions include:

- Water Institute of Southern Africa (WISA)
- A member of the South African Committee for the International Association of Hydrological Sciences
- A member of the National Water Resources Planning Systems User Forum
- A member of the technical Steering Committee of the Working for Water Hydrology Review Panel
- A member of the Committee of the South African Environmental Observation Network (SAEON)
- A member of the National Disaster Management Advisory Forum (DPLG)
- A member of the National Advisory Committee on Water Resource Modelling
- A member of Working for Wetlands Steering Committee
- A member of DWAF technical advisory group on water systems analysis (DWAF TAG)
- A board member of Ecolink (a NGO)
- A member of the Special Water Allocation Reform Core Strategy Team (DWAF)
- A staff member was nominated to serve on the South African Institute of Civil Engineers (SAICE) national water engineering committee
- After rejuvenation, the Working for Water (WfW) Review panel was re-convened. A WRC staff member was invited to be a part of the hydrology research review panel
- During September a WRC Research Manager participated in the SANCIAHS Organising Committee. He was one of a panel of 3 who was tasked with reviewing the submissions for the SANCIAHS Bursary Awards. He was also involved in handling the prize-giving ceremony where student bursaries were awarded to winners
- A WRC staff member is part of the DWAF project steering committee for the National Radioactivity Monitoring Programme
- A staff member is part of the South African Power Utility Research Advisory Board (Eskom).

The WRC continued its involvement in a number of existing national initiatives and has spearheaded new initiatives where the WRC plays key roles:

- The WRC was part of the technical committee for the UNESCO HELP Symposium which was held in November 2007.
- The WRC continues to play the central secretarial role for the UNESCO IHP South Africa. The WRC was represented in their UNESCO Science meeting and was tasked with discussing the UNESCO General Meeting Draft Resolution which will be ratified in October 2007. The joint initiative of the WRC, UNESCO IHP, WISA and DWAF tasked with organising an international conference in March 2008 on IWRM and its suitability for emerging economies and fledging democracies started with the inaugural meeting of the technical committee in June 2007.
- The WRC is working on the details for supporting DWAF on a national Compliance, Monitoring and Enforcement Programme.
- A Research Manager attended the 2007 WfW Project Flagship Symposium as part of his functions whilst serving on the WfW review panel on Hydrology.

The KSA has facilitated the authors, writing workshop for the book on the Policy Frameworks for Transforming Water management in South Africa 13-15 March. The KSA is the lead author for the chapter on 'Democratising Water Management through Institutional Reforms'.

Discussion forums were held with a number of local stakeholders to introduce the KSA research portfolio and strategic intent. This includes meetings with the Inkomati CMA, the Human Sciences Research Council, between Siemens and DWAF, Intercede joint venture between CSIR and SIWI on Transboundary Waters.

The KSA is a partner in the new Challenge Programme project on general authorisations in support of Water Allocation Reform together with Zimbabwe, Mozambique, Zambia and Burkina Faso.

Strategic positioning

- The KSA has facilitated an attempt for the training of the Parliamentary Portfolio Committee on Water Affairs and Forestry in Water Regulations and Law by the International Development Law Organisation (IDLO). The venue and date for the training are not yet finalised.
- The KSA organised a brain-storming session with the new Policy and Social Strategy Team at the HSRC for future strategic partnerships pertaining to gender in the Water and Society Impact Area.
- A strategic meeting with the Inkomati CMA board has been organised for 21 June to identify future research needs and training partnerships with the first CMA in South Africa.
- The KSA participated in the latest WSSLG meeting.
- The KSA has facilitated and organised a sector-wide discussion paper and workshop on Climate Change which was hailed as a much needed get together and a high quality discussion paper which should collate sector-wide initiatives and be published for wider dissemination.
- The KSA was part of a discussion group on water in SADC upon invitation by SAICE.
- Initial discussions on the role of the KSA in the Hartbeespoort Dam DWAF R5m intervention plan took place. It was decided that the WRC will be completely responsible for the R&D support of the implementation project under the implementing agent agreement with DWAF. The project will start once the Rand Water dismissed project managers can be replaced.

Public appreciation

The research project on EDCs at the Rietvlei Dam proved to be highly controversial. Media personnel inundated the WRC with queries and questions. The WRC media officer informed journalists, including the journalist from the Mail&Guardian, that the research report on EDCs was not yet ready for publication. However, the journalist from the Mail&Guardian went ahead and published a sensational article on the topic. The WRC submitted a detailed response, outlining discrepancies and correcting misleading information which was published in the Mail&Guardian the following week.

The WRC also formulated and introduced a media policy to members of executive as well as research managers. The rationale of introducing such a policy was to equip potential media spokespersons with a guideline document on how to handle media matters. During September Die Beeld published sensational articles on EDC contamination at Rietvlei Nature Reserve. The WRC counteracted by issuing a media release and correcting inaccuracies and inconsistencies.

Citations

Report TT 305 – A manual for cost benefit analysis in South Africa with specific reference to water resource development (Water Wheel Jan/Feb 08 – Vol 7 No 1 p 6)
Report TT 304 – Integrated water resource management plan guidelines for local authorities (Water Wheel Nov/Dec 07 - Vol 6 No 6 p 7)
Report KV 185/07 – Bridging scour knowledge through research (Water Wheel Sept/Oct – Vol 6 No 5 p 12-15)
Report TT 303/07 – Groundwater Sampling (Second Edition) (Water Wheel July/Aug 07 – Vol 6 No 4 p 5)
Report TT 286/06 – Project sheds light on underground water (Water Wheel May/June 07 – Vol 6 No 3 p 15-17)

Impact studies

The WRC is finalising an impact study on water management research in South Africa from 1991 to 2006.

African initiatives

- The KSA attended the preparatory African Science Academy Development Initiative Planning Meeting and Workshop in Dakar on 2-4 May 2007. The African Science Academy Development Initiative (ASADI) is organising an annual Africa-US symposium and joint working session spanning the 10 years of the project in November 2007. A major underlying goal of these ASADI annual meetings is to use the theme of the conference as a vehicle to help African academies explore their role with respect to evidence-based advising for policy in their respective nations. The conference theme was Water and Health.
- The KSA is actively involved in the Inter Academy Programme for Water and a staff member attended a meeting (during May) of all leading Science Academies (WRC representing South Africa). During this meeting it was agreed that the WRC will develop and lead an IWRM course for Africa with the theme of Hydro-Energy.
- A KSA staff member is serving as an executive member of the Limpopo Challenge Programme (WaterNet).
- The KSA coordinated a UNEP workshop held at the Farm-Inn (July 2007), where 5 representatives of five African Sub-Regions attended. The WRC led the South African region and was tasked to assess the quality of the report (by collating, editing, and printing). Printing was to be finalised by the end of the year. Reports were refined and sent to international reviewers and the report is expected to be finalised by March 2008.
- Support was provided by the KSA to the South African Academy of Sciences for mobilising South African researchers to take part in the Regional Annual Academy meeting to be held in Dakar this November
- A KSA staff member formed part of a technical task team that developed the Terms of Reference (ToRs) for an African Groundwater Commission for AMCOW.
- African Water continues to make progress and has come to its conclusion in a final meeting with the European Commission, as the contractor in Brussels late in December 2007. The closure recommendations include future leadership of the WRC, especially in enhancing the coordination of African researchers' participation in global research consortia.

International initiatives

The KSA, together with DWAF and WISA, hosted the HELP (Hydrology for the Environment, Life and Policy) Symposium in November 2007. This is a major UNESCO Conference held in South Africa. The Symposium was entitled 'Local Solutions to Global Water Problems – Lessons from the South'. The conference was a resounding success according to the more than 100 delegates who attended from around the globe.

- The KSA continues to represent the South African Academy of Sciences in discussions addressing the development of capacity for managing water resources by the Inter Academy Programme for Water (IAP) (see above).
- The KSA continues to lead the water management area of cooperation between Spain and South Africa as part of Spanish-South Africa bilateral cooperation on science and technology. The focus areas, under water management, are groundwater and hydrology. This was highlighted during the bilateral meeting held in South Africa in October 2006, where a high powered delegation from Spain visited South Africa.
- The KSA delivered an address, upon invitation, at the UNESCO IHE symposium on the occasion of its 50 year anniversary entitled Water for a Changing World: Enhancing Local Knowledge and Capacity.
- The Swiss Federal Institute of Technology, Zurich requested a KSA keynote address on the impact of research on policy. The event was the inauguration of the North South Centre for promoting research and education in the field of international development and cooperation on 29 June 2007. The title of the launch is 'Relevance and Impact of Research for Development' http://www.zil.ethz.ch/news/inaugurationnorthsouthcentre/programme
- The African Water project with the EC is planning for its West Africa and East Africa training sessions.
- A WRC staff member contributed to a training session on IWRM in the Philippines as a result of an invitation by the Phil CapNet and the Davao City Water District Authority. The contribution enhanced the realisation of South East Asia of the vast strides taken by RSA in IWRM. Further bilateral initiatives will result from this interaction.
- The SAFewater (the French-South Africa cooperation for research on water) Annual Report was submitted to DST as per management contract with the WRC. The project is making good progress and DST made funds available for the second phase of the project.
- A KSA research manager manages the WRC WaterNet Project, which is a UN PN17 project on behalf of the WRC
- A KSA staff member is responsible for coordinating the Olifants IWRM Project which involves two German teams and IWRM work in the mid-Olifants. The project deals primarily with hydrology and the economics of using water in a water-scarce area.
- A KSA research manager was nominated to be the WRC representative on the 2010 Soccer World Cup Water Sector Forum.

GROWING THE KNOWLEDGE BASE

Capacity-building initiatives

The table on page 15 illustrates the number of post-graduate students who benefited from WRC-funded research in this KSA in 2007/08. This is in line with the set targets.

Organisation	Students from PD background	Total number of students
Central University of Technology, Free State	1	2
Conningarth Economists	2	4
CSIR	7	12
GEOSS	1	3
Groundwater Africa	1	1
Maluti Water	0	0
Ninham Shand	0	2
North-West University (Potch Campus)	3	9
Pegram and Associates	4	5
SAWS	2	3
Source Strategic Focus (Pty) Ltd	2	3
SRK	6	8
UCT	3	7
UFS	4	10
UKZN (PMB)	8	16
UP	5	9
US	7	14
UWC	30	38
Venda Univ	2	5
	88	**151**

In total 18 project leaders are **women** (in 06/07 the total was 16) and 9 project leaders are **Black males** (9 in 06/07). This figure represents approximately **28% and 14%**, respectively of total projects (was at 24% and 15% respectively in 2006/07).

The KSA participated in a number of initiatives contributing to the water-centred knowledge base in South Africa. These initiatives included participation at open days and arrangement of technology transfer workshops (including participation). During the course of 2007/08, staff participated in both the WRC open days held at the Hartbeespoort Dam and the internal open day in the WRC. The following **workshops** were held in support of research outcomes:

- The WRC hosted and facilitated a workshop, on 5 December 2007, entitled 'Status of Isotope Hydrology in South Africa'. The workshop specifically dealt with the isotope measuring facilities as well as available expertise and capacity building.
- The KSA, in collaboration with the Western Cape Department of Agriculture, organised a workshop on satellite imagery in October in Stellenbosch.
- The KSA has facilitated and hosted 3 workshops of the inaugural capacity building national programme FETwater Phase 2 networks on:
  - beneficial use of water
  - groundwater
  - CMA Expertise networks.
  - On 20 July a workshop on wetland rehabilitation was held in Durban. Participants included the WRC, the University of KwaZulu-Natal (UKZN) and wetland specialists (Project no 1408).
- The KSA together with the CEO met with the new DWAF Infrastructure Agency Manager Ms Majija to discuss strategic partnerships and future collaborations.
- A water sector regulations reference group meeting was attended on 26 October 2007.
- The KSA was part of a ministerial workshop on institutional reforms to study different options of water resources management.
- A climate change national workshop was held on 28 November 2007 to define the WRC research priorities for the next 5 years.
- The KSA is part of the WISA 2008 organising committee and has attended a number of planning meetings.
- The KSA is a partner in the Challenge Programme new project on 'water economies and legal issues' shared with Zimbabwe, Mozambique, Zambia and Burkina Faso. The planning meeting was organised by IWMI.
- The water colloquium on climate change was attended by the KSA.
- The Women in Water awards event was attended by the KSA on behalf of the WRC. Dr Sue Hart (82 years old) was nominated by the KSA and she received a special award on career achievement through the environmental NGO Ecolink.
- A Kenyan delegation was hosted by the WRC where the KSA made presentations.
- By invitation from SAICE, the KSA took part in a SADC roundtable discussion on research and capacity building.
- The KSA made contributions to the WRC Internal Open Day held on 20 September 2007.
- As the secretariat for the UNESCO IHP national committee, the KSA led the organising process for the next IHP regional meeting to be held on the 12 and 13 March 2008.
- The KSA attends the DWAF Water Allocation Reforms Steering Committee.

Scientific presentations and other scientific activities by staff members

- A presentation was made to the Water for Local needs, the contribution of local government to IWRM from 9-10 July 2007 in Johannesburg.
- Two workshops were held with DWAF on the Compliance, Monitoring and Enforcement project and on the Hartbeespoort Intervention Plan Framework.
- A KSA staff member lectured at the universities of Pretoria and Free State on groundwater recharge and groundwater management, respectively.
- A KSA staff member acted as an external examiner for the University of Stellenbosch.
- A KSA staff member acted as an external examiner for the IWRM course of the University of KZN
- A staff member was co-author of a reviewed scientific paper in an IAH publication: Conrad J and Adams S. GIS based assessment of groundwater recharge in the fractured rocks of Namaqualand, South Africa. In: Krasny J & Sharp JM (eds.) Groundwater in Fractured Rocks. Selected Papers on Hydrogeology Series, SP9. International Association of Hydrogeologists. Taylor & Francis, Andover, UK. ISBN: 9780415407458.

Some other external workshops/conferences

A successful knowledge café type of discussion was held as part of a series of these discussion groups to deal with WRC published research critiqued and elaborated on by professors and their respective graduates in a debate format. The success of the first debate held on 4 October 2007, has promoted further engagements of this type to further the WRC efforts in ensuring knowledge sharing.

Euro-Africa-ICT

The EuroAfrica-ICT Conference was held at the CSIR International Convention Centre on 28-29 March. The theme was 'Connecting sub-Saharan Africa & the European Union for ICT Partnerships under FP7. Ms Eiman Karar, Director: Water Resource Management, delivered a talk entitled 'The African Water Initiative'. WRC publications were also distributed to delegates at the conference.

Empowering Rural Women

The 4th World Congress of Rural Women was held in Durban on 23-26 April 2007. The event, which occurs every four years, was hosted by the Ministry of Agriculture and Land Affairs. It was preceded by an African Consultation of Rural Women. The theme of the congress was: 'United in Our Diversity: Working Together towards the Total Emancipation of Rural Women from Poverty and Hunger'. The aim of the congress was to discuss universal issues confronting rural women and to share concrete experiences in addressing these worldwide. Issues include globalisation; trade; sustainable development (social, economic and environmental); gender equality, food security and related issues of access to land, water, finance, new technologies, transport and roads; rural housing; women's health; governance and the impact of public policies on rural women. About 2 000 delegates attended the congress. Ms Eiman Karar attended the event and the WRC exhibited at this event. A special CD was produced which contained WRC reports relating to the congress theme.

The 13th SANCIAHS Symposium

This symposium was held on 6-7 September 2007 in Cape Town. A total of 116 delegates attended the 2-day conference which comprised 69 papers delivered over 21 sessions and covering topics across the water resources spectrum. The event provided engineers, scientists and managers in the hydrology field to network and participate in discussion forums relating to the latest research trends and developments. The WRC was a major sponsor: Graduate Participation Support was provided (R12 000) as well as sponsorship of prizes for the 1st, 2nd and 3rd best symposium papers (R4 200 in total). The WRC also exhibited at this event and various WRC publications were made available.

The 2007 Biennial Groundwater Conference

Approximately 254 delegates from across South Africa and internationally registered for the 3-day South African Biennial Groundwater Conference held from 8-10 October 2007 at Ilanga Estates in Bloemfontein. This conference of the Groundwater Division of the Geological Society of South Africa draws groundwater practitioners, researchers, regulators and other interested parties from across South Africa, Africa, Europe, Asia and North America. A wide variety of papers were delivered on topics including groundwater regulation and governance, aquifer characterisation, surface-groundwater interaction and groundwater pollution and quality. The conference provided an opportunity for geohydrologists, regulators, engineers and environmentalists to obtain information, interact with the major role-players in South Africa and understand the latest trends in groundwater management and assessment. The WRC exhibited at this event and WRC reports and publications proved to be popular.

HELP Symposium

The UNESCO HELP Symposium was held on 4-9 November at Emperor's Palace, Johannesburg. The conference was attended by the Minister of DWAF and Prof Kader Asmal as well as approximately 180 water scientists, policy and law experts from over 25 countries. The conference was hosted by the WRC, DWAF, WISA, IWMI, and UKZN. The WRC was one of the exhibitors at this high-profile event and WRC reports were received favourably.

FP7 Workshops

The European Union's Seventh Framework Programme for Research and Technological Development (FP7) was launched at the beginning of 2007. This funding programme will run for 7 years, with a total budget of over 50bn euros. The WRC coordinated this initiative and held various workshops. The latest workshops were as follows:

- The FP7 Workshop held on 15-16 November 2007 in Dakar, Senegal (representing the Western region of Africa)
- The FP7 Workshop held on 27-30 November in Nairobi, Kenya (representing the Eastern region).

IMPLEMENTATION PLAN

Research portfolio for 2007/08

The primary objective of the research in this KSA remains largely the same as developed in the previous year's business plan. However, the secondary aims have been streamlined to reflect the needs analysis process. Thus the primary objective is to ensure that water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research portfolio for 2007/08 addresses this primary objective as reflected by the following revised secondary objectives/aims, which are to:

- Improve water resources information systems and access to data
- Achieve integration between surface and groundwater research. A programmatic approach will be designed addressing the need for joint studies
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impacts on humans)
- Broaden the scope for policy and institutional studies to deal holistically with the legal, economic, compliance and implementation aspects.

The research portfolio for 2007/08 is presented in Table 1, which provides an overview and description of research thrusts and programmes. The plan reflects changes in the portfolio from the previous plan based on feedback from the needs analysis, and consultation with stakeholders and Board input. These are:

- Redefining the thrusts and programmes as reflected in their descriptions
- Introducing the new programme dealing with catchment data and information systems
- Integrating groundwater and surface water in both Thrusts 1 and 3 through common assessment, planning and development as well as protection
- Replacing low flows and streamflow reduction activities with integrated river flow hydraulics
- A substantially changed Thrust 4 to look at needs identified by the sector such as new developments in compliance, futuristic scenarios, pricing and economic implications from new reforms. The international institutional aspect remains the same to satisfy the continued research needs.

An overview and explanation of thrusts and programmes for KSA 1 for 2007/08 is given in **Table 1**.

TABLE 1

Overview and description of thrusts and programmes

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Scope: This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning. The thrust will promote better understanding of the variability of the quantity and quality of water available for use and development in South Africa. Recent changes in national water resources infrastructure management, the awareness of the poor state of water resources infrastructure and increased knowledge of water resource planning needs are expected to receive attention, through the support of competent and sustainable solutions. Sound water resource assessment and planning can only be achieved with reasonably accurate and consistently recorded and processed data and information. The thrust will support the implementation and use of a national water resource information system.

Programme 1: Catchment data and information systems	**Scope:** This programme will support the provisions of Chapter 14 of the National Water Act, especially **Part 2:** *National Information Systems on Water Resources.* This programme is focused on supporting the national initiative for improving the available water resource information, better management of the information and improved information dissemination to stakeholders. It will establish direct linkages to the national information systems as well as identifying and resolving water resource information gaps. In this programme researched water resource information will be integrated into the national information system that is being established by DWAF. The programme will also support the process of decentralising identified water resource data and information from broader national perspectives to detailed and highly resolved local and catchment scales.
Programme 2: Surface water / groundwater hydrology	**Scope:** This programme focuses on developing and utilising integrated hydrological approaches in surface and groundwater assessments, water resource explorations, planning and management. It will take advantage of gains made in improved understanding of groundwater and surface water hydrological processes as well as the availability of better hydrological data especially the various forms of more accurate remotely sensed data with better coverage. Through this programme, strategic partnerships with international expertise in both groundwater and surface water hydrological research will be encouraged to flourish. Hydrological tools that have been developed in the past are expected to be upgraded, redeveloped or replaced by tools that are more suited to the current data availability, the improved knowledge and the recent technological advances in hydrological modelling.
Programme 3: Water resource planning	**Scope:** This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps such as the absence of reliable information in ungauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water systems plans that will benefit from real time, historic and stochastic data on a countrywide basis. Impacts of climate change on water resources and the planning processes will be accounted for so as to ensure a proactive approach and allowing for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs which have to account for other factors such as national strategic importance, poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals.
Programme 4: Water resource development	**Scope:** This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges and economic growth target of 6% of GDP per year will require thorough understanding and assessments of alternative sources of water. Such sources could be built into future projections for new water, virtual water, water transfers be they national or international, desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. Effort will be applied to the development of solutions for supporting and complimenting the processes and strategies pursued by the Water Infrastructure Agency.

Programme 5: Climate change and hydro-climatic variability	**Scope:** The goal of this programme is to better forecast the variability of rainfall, flow and groundwater recharge. The ability to forecast at very short time scales (48 hours down to a few hours ahead) would greatly benefit flood management and disaster mitigation activities. At longer time scales (e.g. inter-annual or seasonal scales) the ability would greatly assist decisions concerning seasonal water allocation to various users and the environment. Forecasting models range from the empirical (based on statistical relationships which use various oceanic and atmospheric predictors) to the mechanistic (based on the use of dynamic models encapsulating best understanding of influential atmospheric and oceanic processes). This programme will also seek to improve the understanding of climate change for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and mitigation. Through this programme support will be provided for weather and climate disaster mitigation programmes at various levels which will include regional, national, provincial as well as other more localised scales.
Programme 6: Water resource quality management	**Scope:** The quality of water is an important factor in determining the quantity of water that is potentially available for productive use. Determining the amount of water available for different uses is further complicated by the considerable variation that exists in quality requirements between and within different user groups. This programme is aimed at developing and refining fitness-for-use criteria, developing the means to monitor and assess water quality at regional and national levels, improving the manner in which water quality information is conveyed and the identification of emerging water quality issues. The programme also seeks to investigate and apply water quality control and mitigation measures.

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Scope: Research in this thrust focuses on developing appropriate quantitative understanding, tools and strategies for managing the impacts of climate variability and change as well as human interventions on the hydrological cycle and related water resources, with the aim of supporting the development of policy responses, at regional, national or catchment scale, to existing and emerging problems. This includes development of systems (e.g. river flow and inundation forecast models, drought impact monitoring systems) for managing floods and droughts. The focus in this thrust is on the prediction of climate change consequences, the mitigation of floods and droughts and the effects of those on the resources and the people who rely on these resources, with special emphasis on the health impacts from microbial contaminants.

Programme 1: Developing predictive tools and adaptive measures to global climate change	**Scope:** The need to prepare the country to cope with global climate change is of paramount and strategic importance. Taking the view that water is South Africa's key resource implies the need to adapt water resource management progressively as global climate change progresses, in order to maintain optimal levels of both resource protection and beneficial use of water for society. The development of coping strategies will require the development of informed, quantitative scenarios of potential impacts at regional and catchment level on rainfall regimes and rainfall variability, hydrological and geohydrological regimes, water availability and reliability, water quality, ecosystem structure and functions and ecological processes. The following key questions thus need to be considered and addressed in this programme: What confidence can be placed in current GCM-generated scenarios of global climate change? How reliable are current techniques for the downscaling of scenarios from global to regional and catchment scales? At which point will anthropogenic climate change in the Southern Africa context become detectable and distinguishable from natural climate variability and which monitoring systems need to be in place in this regard? How will the frequency and magnitude of extreme rainfall and flow events be affected? Can existing conceptual and numerical models utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely interrelated land use, ecosystem, hydrological (including geohydrological), water yield and water quality changes at regional/catchment level? How will existing management strategies and tools need to be adapted? What are the main socio-economic impacts likely to be, given the structure of society in Southern Africa, and what are appropriate technological, social and political coping strategies?
Programme 2: Human-induced impacts	**Scope:** Various kinds of human activities can influence the quantity, quality, reliability and ecological health of water resources, including activities which take place in other environmental compartments within the hydrological cycle. This programme includes research to improve our ability to assess, evaluate and predict the effects on surface and groundwater resources of human activities and human-induced impacts, with a view to developing strategies for management and mitigation of health impacts.
Programme 3: Integrated flood and drought management	**Scope:** Flooding and drought are major natural hazards to human society and have important influences on social and economic development. This programme focuses on research that will result in the development and implementation of integrated institutional frameworks and technological tools to reduce and combat floods and their negative effects while enhancing positive flooding patterns that are important to the natural ecosystem. Research related to drought management will focus on integrated tools and strategies for early identification and mitigation of the social and economic impacts of drought, with the aim of supporting collaborative, multi-institutional processes and programmes.

THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation.

Programme 1: Protection and management of surface water and groundwater quality	**Scope:** Urban and industrial activities expose groundwater and surface water resources to a range of chemical and microbiological pollutants. This programme investigates the natural and anthropogenic occurrences of hazardous constituents with the aim of developing strategies to minimise the negative impacts on groundwater and surface water resources. The development of improved pollution prevention, control, detection and remediation strategies is essential for the effective management of the water resources. The programme addresses both point and non-point sources of pollution, resulting from activities in the subsurface and/or on the surface. More than 90% of South Africa's aquifers occur in fractured rock. An improved understanding of the fate and transport of pollutants in these fractured-rock environments will be one of the main outcomes. Sampling protocols will be developed for radiogenic elements and non-aqueous phase liquids (NAPLs) in these fractured-rock environments.
Programme 2: Urban and rural water resource management	**Scope:** An integrated approach to water resource planning and management is essential to the sustainability of urban and rural water resources. In many urban and rural areas, water shortages stem from improper use and degradation of the available water by pollution. The outcomes of this programme will enhance the capabilities of local authorities to protect their resources in a sustainable manner through the development of, among others, groundwater protection zones and improved land-use planning. Specific tools will be developed to facilitate the management of these resources.
Programme 3: Integrated river flow and catchment hydraulics	**Scope:** Research in this programme is focused on establishing and maintaining high-quality river flows, reduction and mitigation of river degradation which is caused by river hydraulic processes such as damaging flow regimes, sediment transportation and deposition. The programme will also integrate improved catchment management as part of a holistic strategy for the protection of groundwater and surface water resources. The programme will seek to establish processes and practices that will ensure minimum disruptions to natural water flow regimes especially low flows which usually result in periods of critical water constraints in river systems. The groundwater and surface water processes which are associated with the critical flow regimes are also investigated in this programme.

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders based on catchment and water management area boundaries. The marked shift from central management of resources to more localised scale is critical to the main founding concepts of IWRM. The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept.

This thrust will support the suitable implementation of IWRM in South Africa. The further articulation of the NWA for the benefit of all South Africans and the fulfilment of the developmental role of the state within the water resource limitations will be investigated. Lessons learnt and evaluations of the IWRM applications in South Africa to date will be part of this portfolio focusing on home-grown approaches and experiences in water resource management.

The thrust supports research on tools and methodologies for decision support in IWRM which aims at providing strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures. These structures are for implementing IWRM, through;

- Future projections based on scenario building
- Bridging the gap between WRM and better services
- More emphasis on enforcement and compliance
- Addressing financial provisions and institutional sustainability challenges
- Better understanding of internationally shared water resources in support of NEPAD.

Programme 1: Institutional governance and reforms	**Scope:** The principle of subsidiarity, or as it is sometimes referred to as democratisation of water resource management, has brought about challenging concepts, both conceptually and in terms of application. Although current reforms in South Africa are based on sound IWRM principles, to date the implementation thereof continues to break new ground, proving that institutional engineering cannot provide a one-size-fits-all solution to the new management paradigm. Further understanding and research are hence needed to learn and decide on best practice as defined in the South African or similar socio-economic settings.
Programme 2: Compliance and enforcement	**Scope:** For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is at its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Bench-marking and best practice are crucial here to learn from lessons.

Programme 3: Pricing and financing WRM	**Scope:** The issues of financial sustainability, affordability of charges by users, transparency and corporate governance aspects are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good ground-breaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource charges exclude the poor and will it further cripple local government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.
Programme 4: Transboundary water resources	**Scope:** This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.
Programme 5: Future scenarios	**Scope:** This activity has been warranted a separate programme to ensure that local South African expertise is qualified to explore future scenarios and answer the 'what if ' questions in support of reflection and evaluation of national policy applications. Projecting the water resource management and development institutional arrangements landscape 10 or 15 years from now would be of interest to decision makers to define policy reviews and enhance decision making. Further complexity can be added on through the introduction of the water services institutions. Mapping of the processes for tariff setting between both water resources and water services could allow further investigation into service delivery affordability and efficacy. This programme is likely to have a phased programmatic approach to adding more and more layers to the scenarios and for them to be customised for localised aspects that need not be of national interest.

RESEARCH PROJECTS FOR 2007/08

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The value of water as an economic resource in the Great Letaba River catchment
Economic Project Evaluation (Pty) Ltd
No 989

The Letaba water management area lies entirely within the Limpopo Province and forms an integral part of the Limpopo Basin. The study area comprises the Groot, Klein and Middle Letaba catchments.

The aims and objectives of this study were amongst others to determine the water balance in the catchment and model the water demand schedules for the irrigated agriculture, forestry, eco-systems and household sectors. These water demand schedules are simulated through the use of various modelling techniques. The approach employed is to use contingent valuation methods for direct demand (municipal water), and enterprise budgets and linear programming, or enterprise budgets with crop water production functions for derived demand (forestry and agricultural water).

Following the above-mentioned modelling approach, it proved possible to produce a suite of models which enabled water demand schedules to be generated for the four water-using sectors covered by this study. In addition, means were provided to integrate these results and to explore and bench-mark water-use scenarios. This included allocating water according to the principle of maximisation of net social payoff, which was used in this study as a proxy for social welfare.

Having explored the various models, and verified their operation, it is considered that much useful work still needs to be done to remedy many of the shortcomings of this study. This requires mainly that adequate data should be available for research. Further work should therefore be done on identifying and assembling more accurate and appropriate data.

Cost: R795 625
Term: 1998-2002

Towards integrated catchment management in the Mlazi River: A model for participation in the South African context
Farmer Support Group, University of KwaZulu-Natal
No 1157

In 1994, various residents, resource managers and researchers with an interest in the area around the Ntshongweni Dam were approached by Raymond Auerbach concerning social and environmental problems in the area. Although then research coordinator for Farmer Support Group, he was at the same time also a local farmer in a small sub-catchment of the Sterkspruit, a tributary of the Mlazi River. With the help of seed funding from Umgeni Water, and the positive engagement of many people, information was gathered, a proposal was submitted to the WRC and an initial Catchment Management Workshop was held in November 1994. At this point, the focus was on the Sterkspruit (or *Mncadodo* Stream), the Nthsongweni area and dam, and the Mlazi River between Mpumalanga township and the dam. The programme was called the Ntshongweni Catchment Management Programme (NCMP).

When WRC approved the pilot proposal for 1995 and 1996, three more staff members were appointed in addition to the coordinator (ecologist; catchment development facilitator; agriculture facilitator). Activities gathered momentum, with a remarkably positive response to the pamphlet (published in 1996) 'Do you care about your catchment?' At the end of 1996, WRC agreed to double the level of support to enable the appointment of a publicity and information officer, a craftwork facilitator, an environmental educator, an office manager, a conservancies consultant and later an upper catchment agricultural facilitator (with help from Mondi), and a conservation officer (employed by the Umlaas Irrigation Board's Catchment Project). These 11 people have undertaken a remarkable range of activities over the past 6 years. Together with 6 Dutch students and several more South African students, they have built up a body of experience in integrated catchment management (ICM). The programme has grown from a small core of activities in one sub-catchment, to a more comprehensive attempt to bring people together throughout the Mlazi River catchment, and also influences Metropolitan Durban

through staff involvement in developing an Environmental Management System based on an understanding of the importance of ICM. The name of the programme has now been changed to the Mlazi River Catchment Programme (MRCP) to reflect this more comprehensive scope. However, as a lower level of support was given to the third phase of the programme, activities could not be extended into the lower catchment, and the staff complement was reduced from 10 staff members to 5.

The main activities of the programme can be described under the headings water demand management research, environmental education, rural development and community capacity building, local government development and environmental monitoring. In each of these fields, a considerable number of activities were undertaken, representing technical, social and ethical aspects of catchment management.

Cost: R1 000 000
Term: 2000-2001

Update of SA Atlas of Agrohydrology and Climatology
University of KwaZulu-Natal
No 1489

The *South African Atlas of Agrohydrology and Climatology* is an illustration of the diversity of South Africa's biophysical make-up – its climate, agricultural production and the water related environment. In this project accumulated data, information and knowledge was processed into a set of electronic map coverages for the South African region. In this project, this is the region defined as the contiguous geographical entity comprising the 9 provinces of the Republic of South Africa plus Lesotho and Swaziland.

In the Atlas project the agroclimatological and agrohydrological data and information from various research projects were collated into a coordinated spatiotemporal database. The databases were used in the production of the updated and extended Atlas. New soils and baseline land cover information was used in the project while revising optimum climatic growth areas, yields and the inter-annual variabilities of a range of crops. In this project, the research team also acquired skills in database structure and management in order to develop, test and validate the interactive Atlas and the metadata that underpin the project.

This project also presents the diverse nature of South Africa's inhabitants and the socio-economic milieu which, on the one hand, they have shaped and which, on the other hand, they have responded to either voluntarily or involuntarily through history, politics and the physical environment. This background is given at the geographic scale of provinces, by demographic indicators, educational indicators, socio-economic ones or those related to personal conveniences. The statistics for the RSA have been derived from the 2001 population census (Statistics SA, 2003).

This Atlas is expected to be used at national, provincial and local government departments, by aid agencies, NGOs, parastatals, overseas research institutes, engineering/environmental consultants and agricultural producers as a reference work and by universities/technikons as an essential Atlas.

Cost: R546 100
Term: 2004-2006

Programme 3: Understanding and predicting hydroclimatic variability

Hydroclimatic variation over Southern Africa at intra-annual and inter-annual time scales, with special reference to the role of the oceans
Department of Oceanography, University of Cape Town
No 1476

South Africa experiences dramatic inter-annual changes in rainfall, characterised by severe droughts and wet spells. Over the last 15 years much knowledge has been gained on how the oceans can modify the global climate and affect the rainfall of Southern Africa, from the decadal to inter-annual scales. Previous research has shown that many droughts in Southern Africa occur during the mature phase of El Niño, when the central and eastern Pacific and the Indian Ocean are warmer. Conversely, wet spells are more likely to be experienced during La Niña conditions. The behaviour of equatorial and tropical oceans has a profound effect on the world's weather patterns due to their high sea surface temperatures and elevated heat contents of the first 100 metres below the surface. Southern Africa's inter-annual climate variability is also impacted, but in a manner that does offer some predictability depending on how well ocean-atmosphere processes are understood. Although the El Niño-Southern Oscillation (ENSO) phenomenon is the dominant regulator of Southern Africa summer rainfall, the Indian and Atlantic Oceans also play influential roles that need to be understood.

This project set out to enhance understanding the ocean's role in regulating hydroclimatic variability in Southern Africa, thereby moving closer to providing resource managers with the capacity to address issues of climate variability more effectively. Specific objectives were to establish a suitable index for expressing climate variation over Southern Africa from a resource management perspective, and then to examine key ocean-atmosphere processes and their contribution to climate variation by making use of advanced satellite remote sensing products and model-interpolated global datasets.

The Standardised Precipitation Index (SPI) has proved to be highly suitable for characterising and monitoring droughts and wet spells over a range of time scales (3, 6, 12 and 24 months). This was demonstrated in a retrospective analysis of the spatial extent and intensity of droughts in South Africa from 1921 to 2000, which once again revealed the dominant role of El Niño, with two-thirds of the severest and most widespread occurrences being El Niño-associated.

With regard to the role of the ocean in regulating Southern African climate, a better understanding of the mechanisms responsible for variations in sea surface temperature and heat content of the upper ocean layer and their associated atmospheric impacts, particularly in ocean areas that are known to correlate well with Southern African rainfall, are crucial. As a result of investigations designed to enhance such understanding, several new insights have been gained.

Increases in the intensity of tropical cyclones as they traverse the Mozambique channel are clearly associated with the anomalously high heat content of warm eddies that occur in the channel.

Evaporation, an important process which cools the ocean surface and transfers moisture to the atmosphere has not always been well quantified. Over the Agulhas Current retroflection region where evaporation is substantial, large spatial gradients have been found responsible for model-interpolated global datasets typically underestimating heat and moisture transfer to the atmosphere by a factor of three, meaning that a potentially important source of climate variability for parts of South Africa such as the Agulhas current has been largely unrecognised in past research. A further process that leads to cooling or warming of the ocean is heat advection by ocean currents. For this reason, the discovery of a hitherto unknown current named the South Indian Ocean Counter-Current (SICC) is of great significance. The SICC, identified and characterised using satellite remote sensing data, flows eastward from Madagascar between latitudes 22° and 26°S.

Warm and cold surface events that develop regularly along the coast of Angola and Namibia have been shown to be local expressions of large-scale episodes generated by wind anomalies in the western and central equatorial Atlantic. Fluctuations of the depth and shape of the tropical thermocline provide the link between variations in sea surface temperature anomalies off the Angolan coast and ocean-atmosphere interactions in the remote tropical Atlantic. Further south, a clear link has been established between winter rainfall over south-western South

Africa and the Antarctic Oscillation (AAO – an index based on the relative variations in atmospheric pressure between Antarctica and the mid-latitudes), to the extent that 9 of the 11 wettest winters in this area coincided with a negative AAO phase, while 8 of the 11 driest winters were associated with a positive AAO phase. With the AAO leading winter rainfall by approximately two months, knowledge of the AAO phase in early winter, for example, may have some predictive value relating to midwinter rainfall over south-western South Africa. There is a suggestion of a link, also, between the AAO and the climate of Marion Island. Since about 1980, when a well-documented phase shift in the AAO occurred, a concurrent, significant change in the local climate of Marion Island has also been observed. This change includes a decrease in rainfall, increase in non-rainy days, changes in wind speed and direction, increase in maximum and minimum local air temperature and increase in near-shore sea surface temperature.

A range of factors affecting moisture input from the South Atlantic and Indian Oceans over Southern Africa through zonal water vapour transport have been examined and clarified. Ultimately, such studies will contribute to enhancing climate predictability over Southern Africa.

Resulting from the research, a website (http://realtime.sea.uct.ac.za/) has been established to enable anomalies in ocean conditions conducive to droughts or floods in Southern Africa to be monitored and displayed continuously in near 489 real time.

Despite the great strides that have been made, there is still a long way to go to developing an understanding of all the factors that regulate inter-annual variability of Southern African climate. Some of the important questions that have emerged are the following:

- Why is there no linear relationship between ENSO and SA rainfall variability?
- Why are some El Niño events not linked to drought?
- What is the impact of El Niño and La Niña at the catchment scale?
- What is the role of the AAO on summer rainfall?
- What is the interaction of ENSO and AAO and how does this affect Southern African climate?

Many of these questions will be addressed in a follow-on project that has made continuity of the research possible.

Cost: R2 000 000
Term: 2004–2007

Programme 5: Water quality assessment studies and information systems

Development of technical guidelines for water quality use allocation procedures under the NWA through application of the Berg River water quality information system
Department of Civil Engineering, University of Stellenbosch
No 1301

The National Water Act prescribes the minimum components of a catchment management strategy. Prime amongst these are the formulation of water allocation principles and a water allocation plan for each water management area. This Project focused on a very particular part of the allocation challenge, namely the allocation of 'Water Quality Use'. It aimed to develop a conceptual framework for water quality use allocation procedures, and to develop and disseminate technical guidelines for water quality use allocation procedures. The project employed a process of 'learning-by-doing' by applying the framework in a stressed catchment with water quality concerns. The ACRU*Salinity* model was applied to the Berg River catchment because it also offered a ready-made water quality information system (WQIS) previously developed under **WRC Project No 951**.

A review of international best practice in water quality use allocation procedures, with specific focus on the approaches and technical support required to implement these concepts in the USA, the European Union and Australia, revealed a number of common elements in the international approaches. A review of the SA water resource policies that have a bearing on water quality use allocation indicated that the technical components of a Water Use Allocation plan should be guided by the following principles:

- Precautionary principle approach
- Integrated and holistic approach
- Due consideration given to alternative options
- Carrying capacity
- Equity and fairness
- Simplicity.

As part of the development of a conceptual framework for water quality use allocation procedures, it was concluded that the degree of technical support that is required for water quality use allocation is dependent on the degree of water quality stress in a catchment and sub-catchment. The need for higher confidence decision making increases as the degree of water quality stress increases and the complexity of technical support tools need to mirror this. In a water quality unstressed catchment, simple management oriented tools would be sufficient. However, in a potentially water quality stressed catchment, a coarse catchment-scale water quality model would be required. In a water quality stressed catchment, a coarse catchment scale water quality model is required for sector level allocations, and a fine scale river reach or reservoir model is required to support individual allocation decisions at a fine spatial scale.

This approach is aligned with policies that seek to find pragmatic solutions to water quality management and only increases the complexity of the decision-making process and support tools when the situation in the catchment justifies it.

As expected, the ACRU*Salinity* model produced representative simulated flow outputs requiring very little refinement (sub-division) of the verification sub-catchments. However, initial runs with the β-version of the ACRU*Salinity* model revealed that the model was not ready for application in catchments which produces highly saline runoff. This required that a number of changes be introduced. Still the simulated TDS concentrations required considerable calibration, especially for the highly saline catchments. The current module for salinity generation and mobilisation was used for this purpose. The project team is confident that the calibrated ACRU*Salinity* model would allow for the quantification of the effects of further development (e.g. new dam or change in land-use) on the quantity of runoff as well as the quality of the runoff by taking into account the spatial distribution of rainfall, abstractions, imports, irrigation demands and the effect of dams. However, it is recommended that a deterministic module for salinity generation and mobilisation be incorporated into the ACRU*Salinity* model. In this way, the simulation of saline runoff will use measurable (or referenced) salinity related parameters specific to the natural geology and land-use. They anticipate that a current **WRC Project (No 1503: Land-use impacts on salinity in Western Cape waters)** could deliver such a deterministic model for use in ACRU*Salinity*.

Cost: R683 000
Term: 2002-2004

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 2: Human-induced impacts

Fluoride in drinking water and its effects on human health and nutrition (A component project of the research programme on sustainable groundwater management and utilisation in the Northern Cape)
Faculty of Dentistry, University of the Western Cape
No 1094

The project tried to correlate the fluoride concentration in drinking water to the prevalence of caries as well as to assess the nutritional status of young school-going children (including pre-schools) in selected areas of the Northern Cape. The objectives of the project were to determine:

- The levels of fluoride in the groundwater supply used for human consumption in the Northern Cape
- The nutritional status of the selected samples of children in terms of outcomes related to high and low fluoride levels
- Fluoride toxicity as measured by the teeth using the TF Index
- Appropriate and inexpensive technology for safe and sustainable drinking water supply in the Northern Cape.

The study found that fluoride levels of 0.3 mg/l have a beneficial effect on permanent teeth with little effect of primary teeth of children between 3 and 5 years. From the overall study it was found that 20.2% of the children examined suffered from malnutrition or stunted growth.

A total number of 954 school children were examined for nutritional status (height and weight), caries and fluorosis in the Kimberley, De Aar, Leliefontein and Kamassies areas of the Northern Cape. A stratified sample of schools was selected for true representation of the province.

The fluoride levels for Northern Cape ranged from <0.05 to 8.2 ppm. The average fluoride levels of major towns with centralised water supply were between 0.3 and 0.4 ppm. A borehole water supply in De Aar had a fluoride level of 0.7 ppm, 0.2-2.5 and 2.4-8.2 ppm for boreholes in Leliefontein and Kamassies, respectively.

The percentage of caries-free children for 3-5 years old ranged from 25% in De Aar to 45% in Kimberley. The results of the decayed, missing and filled permanent teeth showed very low prevalence of dental caries (DMFT=0.49-1.31) in the 11-13 years of age range in the whole Northern Cape Province. There was no difference in nutritional status of the sample population in the Kimberley and peri-urban areas as well as De Aar. Mild-to-severe fluorosis was seen in different parts of the province. Peri-urban areas in the Diamondfield, Kamassies and Leliefontein areas showed higher percentage TF Index scores of 1-4.

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Cost: R318 000
Term: 1999-2007 (extended)

Community-based research on the influence of rehabilitation techniques on the hydrology of degraded catchments
School of Applied Environmental Sciences, University of KwaZulu-Natal (Pietermaritzburg)
No 1316

The uThukela catchment area plays a vital role in water provision for KwaZulu–Natal and Gauteng. Twenty-five per cent of South Africa's water is generated in this region (Diederichs & Mander, 2004). One of the largest water transfer schemes in South Africa, the Tugela-Vaal, utilises water from this catchment area. The communities that live in these mountainous areas rely on the natural resources which are their only productive asset. However, the lack of effective management plans within these communal areas has had negative impacts on the conservation of natural resources. Large parts of this area are degraded and loss of grass cover on these steep mountain slopes has resulted in poor water infiltration, increased runoff and severe soil erosion.

At Okhombe, a pilot government LandCare project was initiated which embarked upon an intensive job-creation programme which focused on the rehabilitation of degraded areas in the Drakensberg catchment area. The basis of LandCare is that land degradation is a community problem and that people will work in groups to encourage land users to assume responsibility for local problems. The main focus of the LandCare project was capacity building and training of community members in the implementation of a number of different erosion control techniques. The LandCare project was highly successful with most of the rehabilitation areas showing clear signs of stabilisation. However, one of the biggest criticisms of this rehabilitation work is the lack of quantitative information on how successful the different techniques have been. The aim of this project was to develop a community-based monitoring system to determine the effect of rehabilitation on reducing soil erosion and runoff and increasing water quantity and vegetation cover in the previously degraded areas.

The Okhombe Monitoring Group (OMG) which comprised 24 representatives from the 6 sub-wards within Okhombe was formed with the purpose of developing a community-based monitoring system that could be implemented by the group, many of whom had little formal education. The OMG took the responsibility of developing and implementing rehabilitation and monitoring programme for their area. In order to detect changes that had taken place the OMG tested different monitoring techniques on an eroded and rehabilitated site so that the two could be compared. In addition to data collection, the OMG received training on data analysis, interpretation and presentation. The development and implementation of a community-based monitoring programme was an on-going process throughout the 5 years of the project. Modifications to the techniques and data sheets were continually made by the community during this period. In their application of the monitoring techniques the community noted significant differences between the eroded and rehabilitated sites. For example, in Enhlanokhombe from October 2003 to January 2004 basal cover of the vegetation increased from 55 to 71% in the rehabilitated site, but decreased in the eroded site from 33 to 24%. Although the basal cover quadrate is a scientific, quantitative technique, the modifications made enabled it to be easily operated by members of the group, even those who were illiterate.

Overall the OMG mastered the basic scientific skills of communicating the differences made by the rehabilitation work in the form of graphs. One of the main lessons from the project was that social and technological issues must be integrated when developing solutions to environmental problems. The education and training carried out in this project was both a scientific and a social process, bringing people together, and contributing to the development of the community as a whole. The sustainable management of Okhombe is dependent on the ability of the community to recognise and define problems and to generate and implement solutions in an ongoing, dynamic manner. From the start of the project the community were involved in decision making on topics ranging from short-term planning (e.g. date of next meeting, catering) to complex issues (e.g. development of land-use management plans, selecting work teams, establishing a donga committee). This led to the ownership of the project by the community. The monitoring results indicate that the rehabilitation by the community has made a significant decrease in soil loss and runoff. However, no single technique can be recommended for rehabilitation at Okhombe as each technique has specific advantages and disadvantages. The success of a technique depends on the extent and type of erosion, availability of material and how well it is constructed. Through workshops and field days the work teams have built the capacity to evaluate each situation and apply the most appropriate technique.

Cost: R984 000
Term: 2002-2007

Development of a system of simplified methods of vegetation water use based on the principle of limits to evapotranspiration
Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch
No 1319

Water resource managers will increasingly need to assess whether proposed changes in land-use within catchments are likely to significantly reduce

the quantity and temporal availability of water to down-stream users. Such decisions need to be based on the relative annual water use of the existing and proposed new crops or vegetation. The National Water Act makes provision for declaring certain land-covers (forests and crops) as SFRAs but it is likely that other land-cover changes may also have a significant impact in some situations. The principle of limits to evapotranspiration will allow for the limiting factors to be identified in particular situations and thus for a screening of land-cover changes based on the likely impacts. It could also provide a useful framework for interpreting the impacts of regional climate change in South African situations.

In selecting a model to use in this study, the research team considered easy availability of the model, proven scientific credibility and application in hydrological studies, good documentation, a balance between simplicity and realism, and applicability to a wide range of vegetation types. The concept of identifying limits and controls on the process of evapotranspiration (ET) was also key to this project, and central to the development of a broad water use framework. Suitability for linkage to a user-friendly interface to permit model use by non-specialist users was a further consideration. Against these criteria, the WAVES model was selected as the most suitable. The original version of this model was developed by the Land and Water CRC of the CSIRO in Canberra, Australia. In this project this model was revised with permission from the developers to meet the project objectives and adapted to local conditions.

The project aimed at developing a framework of understanding of the major controls of ET in different types of vegetation and crops in South Africa. This research is expected to lead to a better understanding of how changes in land-cover will impact on surface water yields; and also to propose simpler approaches of assessing these impacts, easing the task of simulating water use in the wide variety of vegetation, both indigenous and alien.

The updated WAVES model was simulated to determine ET and transpiration for a variety of land covers. The simulated outputs were compared with field based measurements from scintillometry, Eddy Covariance, Bowen Ratio and heat pulse velocity techniques. It was observed in the project that the WAVES model gave good correlation with measured ET and transpiration for most of the vegetation types. The climate controls in ET were also very evident in the study as the availability of soil water restricted ET which occasionally rose after rainfall and fell in drier periods in the cases of certain shallow root forests such as fynbos. The researchers also noted that, while the plant growth module in WAVES is far simpler than that in many other process-based models, it allows the green leaf biomass to be adequately simulated over time, and models the various constraints imposed on both growth and transpiration.

In this project a user-friendly prediction tool to allow non-specialist modellers to assess the water use of various land-cover types was developed through the improvements to the WAVES model. The version of WAVES developed in this project is a CD-based product that will be distributed with the research report for the benefit of a wide variety of researchers, water resource managers, conservationists and students.

It was also observed in the study that further work will be important to improve the value that will be gained from the use of the updated WAVES model. Important areas for further research work include:

- Linking ET changes to streamflow in a spatial context.
- Parameterising more vegetation types for inclusion in the models. This will ensure that a high priority is given to further species of alien invasive plants that are suspected of bringing about significant hydrological changes.
- Investigating the water use of aquifer-dependent vegetation in the drier parts of the country. This will highlight and enable the regulation of aquifer utilisation to avoid permanent ecosystem damage.

Cost: R1 013 000
Term: 2002-2005

A guide to conduct eutrophication assessments for rivers, lakes and wetlands
Ninham Shand (Pty) Ltd
No 1343

A study commissioned in 2000 by the WRC found that South Africa's policy and approach to eutrophication control has been inadequate over the previous 20 years. A strong need was identified to remobilise and redevelop our capacity to manage eutrophication. A workshop followed in 2001 to discuss research and capacity building within the field of eutrophication. At this workshop *assessment of the eutrophication problem* was identified as the highest priority research area. This project aimed to produce a guide to satisfy the identified need, provide a means through which best eutrophication assessment practice can be captured and made available to practitioners, and develop tools and course material to fast track capacity building concerning eutrophication assessment.

The guide to assess eutrophication related water quality uses the same protocol as the DWAF guide to catchment scale water quality assessment studies and is thus aligned with current DWAF policies and procedures. The guide is structured around 6 management questions that are designed to establish the current eutrophication status, stakeholders, issues and concerns, where the eutrophication status of the area is heading in future, what the appropriate management options are and whether the catchment management objectives have been achieved. For each management question a task has been formulated to provide answers to the management question. The hypertext enabled version of the guide has links to websites where additional information can be found.

The best eutrophication assessment practice was captured in a web-based nutrient enrichment assessment protocol (NEAP). NEAP is based on a range of existing phosphorus load: response relationships. It was designed to provide fast and simple-to-use approximations of the eutrophication level of a particular reservoir, and to identify management options. Should more detailed examination be required, more complex models can be employed as the required data become available.

The outline of an eutrophication assessment short course was developed, with the Eutrophication Assessment Guide serving as the background document. Its primary target audience is water resource practitioners, water resource managers and freshwater scientists. A secondary audience is students at tertiary institutions. The course stretches over two days and consists of an introduction to eutrophication assessment and the context within which a catchment scale eutrophication assessment study is undertaken. The different tasks and sub-tasks are discussed using the guide as manual and the NEAP software is used to undertake a hands-on assessment of a case study.

It is believed that the products of this project will go a long way to address the need for improved means with which to assess the eutrophication problem.

Cost: R669 700
Term: 2002-2004

Minewater irrigation return flow
Institute for Groundwater Studies, University of the Free State
No 1507

Research over a period of more than 10 years that concluded with **WRC Project No 1149**, has provided proof about the shorter term feasibility and sustainability, from an irrigation perspective, of using gypsiferous waters for irrigation of a range of crops. Minimal contamination of groundwater was observed over this period. However, the larger scale implementation of this practice is hampered by concerns of regulators regarding the long-term impact that large-scale minewater irrigation may have on groundwater quality and quantity. This project undertook research at five sites where

gypsiferous water was used for irrigation to determine the hydraulic interaction between irrigated minewater and underlying aquifers, its effect on the hydrology and water quality at opencast spoils and undisturbed areas, salt migration and attenuation, and to establish criteria for site selection and operation.

Soil profiles under irrigation were found to have a high water content, which increases above clay-rich layers. Approximately 80% of the salts applied over the years of irrigation were contained in the top 2 m of the profile, with the top metre being gypsum saturated; 40-50% of salts were dissolved in the soil water, while the balance was either precipitated or sorbed by the soil. Geochemical modelling provided similar results. This implies that over the short to medium term, irrigation did not influence the aquifers to a great degree. Dissolved salts leach to the aquifers at very low rates and are diluted at such a fast rate by the regional lateral groundwater flow, that only low concentrations are detected through borehole sampling. In the short to medium term, the evidence thus shows that irrigation with gypsiferous mine water does not hold significant threats to the regional groundwater quality.

One of the most promising applications of irrigation with gypsiferous water is its application to rehabilitated opencast spoils. These areas have already been impacted by mining and the salts leached from irrigation can be regarded as being fed into the same system from which they originate. Laboratory and field studies, together with geochemical models, were carried out to determine the behaviour of the spoils under various irrigation conditions. The cumulative understanding developed from these studies allowed the construction of feasible conceptual reaction models to predict the outcomes from alternative scenarios. The reactive nature of the spoils is very important in this regard. The potential for acid generation is a very important indicator, while it is also clear that in high sulphide areas, the irrigation will enhance reactions and therefore lead to more rapid acidification and a higher salt load generation. Where recirculation is practised, it is important to use gypsiferous water, as waters with highly soluble constituents will not precipitate and concentrations will continue to rise to very high levels.

The project has developed a set of criteria for site selection/operation, monitoring, determination of impacts, and mitigation methods for irrigation with mine water, which have been combined into a user-friendly software application, entitled 'Groundwater Impacts of Minewater Irrigation' (GIMI). GIMI takes the site-specific conditions of crop types, climate, water quality, soil properties, irrigation water quality, size of irrigation area, spoils geochemistry, aquifer properties and closest receptors into account to recommend whether the irrigation is viable and what monitoring needs to be put in place. All of this should allow mine water irrigation to be considered, managed, regulated and implemented as part of responsible mine water management, with a far higher degree of confidence than was previously possible.

Cost: R445 650
Term: 2004-2007

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater
Council for Geoscience
No 1431

The overall objectives of the project are to provide a basis for the South African authorities to safeguard groundwater consumers from exposure to toxic trace elements, and to determine whether or not leach testing on representative bedrock, or reliable geochemical models can be used to predict natural groundwater contamination in different regions. The trace elements of interest in this project are arsenic, chromium and uranium. The field investigation sought to sample a broad range of geological settings across South Africa and covered the following regions:

- Giyani and Gravelotte greenstone belts
- Eastern Bushveld
- Rooiberg tin fields
- Karoo coal fields
- Bushmanland
- Beaufort West and Sutherland.

The field investigation made the following main findings:
Arsenic was measured in harmful levels in one Giyani and three Beaufort West boreholes. Only one farm borehole was among this group (in Beaufort West) and the rest were mining or exploration boreholes. There was potential for speciation of arsenic in the more toxic arsenite form (As III) at approximately 10% of boreholes, including the Giyani borehole above.
Chromium was not measured in harmful levels in any boreholes, although was present in low concentrations at most. There was potential for speciation in the more toxic hexavalent form (Cr VI) at only one Karoo coalfields borehole.
Uranium was measured in harmful levels in 13 boreholes in Bushmanland and Beaufort West, and at low levels in some others. The boreholes in the former region were mostly located on farms, whilst those in the latter included one farm borehole and two exploration boreholes. According to water quality guidelines, the uranium levels measured on the farms should not pose a threat to most healthy individuals. In general the various leach tests on non-ore-body samples yielded relatively minor quantities of the contaminants of concern for the current study (As, Cr and U). Some higher levels of these metals were leached from some samples collected in mineralised zones; however, water in these areas would not normally be used for drinking purposes. Batch leach test results showed very weak, insignificant correlations with groundwater collected at corresponding sites, for all three elements of concern.

The leaching results support those of the geochemical modelling, in that the naturally elevated levels of hazardous trace elements in groundwater observed in field sampling are unlikely to be the result of simple interactions between groundwater and the surrounding aquifer material. More likely, it is the result of interactions within local mineralised zones within aquifers or recharge areas, or localised anomalous geochemical zones within aquifers.

Cost: R900 000
Term: 2003-2007

Field investigations to study the fate and transport of DNAPLs in groundwater
Institute for Groundwater Studies, University of the Free State
No 1501

Dense non-aqueous phase liquids (DNAPL) contamination is a worldwide phenomenon which has been thrust upon developing countries during recent years. The results of this project are the state-of-the-art for DNAPL related studies in Southern Africa. The project objectives were to:

- Identify flagship field sites where DNAPL site characterisation methods and natural attenuation processes will be evaluated and tested during the project
- Evaluate rapid methods for the delineation of DNAPL contaminated zones
- Conduct field and laboratory scale based studies in order to identify and predict critical factors for DNAPL flow and transport under South African aquifer conditions
- Assess the viability of natural and enhanced attenuation processes of DNAPL contaminated zones
- Establish methodologies for DNAPL site characterisation and Monitored Natural Attenuation (MNA)
- Develop guidelines for the construction of conceptual models of DNAPL contaminated sites
- Develop appropriate guidelines for monitoring systems of DNAPL contaminated sites.

Research on this topic was done on two separate test sites and supported by a diversity of laboratory experiments. Five different products have been delivered:

- *Manual for Site Assessment at DNAPL Contaminated Sites in South Africa*
- Groundwater monitoring guidelines for DNAPLs in South African aquifers
- Guidelines for the acceptance of monitored natural attenuation processes in South Africa
- Handbook for DNAPL contaminated sites in South Africa
- Results of field investigations to study the fate and transport of DNAPLs in groundwater.

Cost: R3 058 000
Term: 2004-2007

Programme 2: Protection and management of surface water quality

The assessment of short-, medium- and long-term impacts on groundwater quality associated with the filling of dolomite cavities
Metago Environmental Engineering
No 1122

De-watering of the dolomitic aquifers overlying ore bearing reefs has, since the 1960s, resulted in the formation of a large numbers of cavities in the dolomitic compartments on the West Rand. Some cavities have been filled with various mine waste materials including gold mine tailings and waste rock. The State Technical Committee for Sinkholes had raised the alarm about the potential for groundwater contamination as a result of this practice. These cavities have to be filled for safety reasons and to prevent inflow of surface water which would aggravate ground instability, accelerate recharge of the mine void and hence increased pumping costs. Slimes material is the most economical material for filling cavities. This investigation focussed on the impact that the future filling of cavities may have on groundwater quality and the effectiveness of alternative fill materials and methods.

On cessation of mining, the water in the dolomite compartment is expected to rise to the same level as was present prior to mining. The time to reach the final level is provisionally estimated to be between 11 and 30 years after mining ceases.

A geochemical model was developed to predict the quality of leachate and its impact on the groundwater in the immediate vicinity (directly below) the backfilled sinkhole over time. With the exception of uranium, the leachate quality from the gold tailings backfill does not pose a significant health risk to humans that use the aquifer in future. Heavy metal poisoning due to groundwater consumption is mitigated by the high pH buffering capacity of the dolomite water which ensures that any dissolved metals entering the aquifer, if not diluted, will be readily precipitated, keeping heavy metal concentrations at safe levels. Uranium could exist in the aqueous form under both acidic and alkaline conditions, only the speciation varied.

A separate model was developed to evaluate the combined effect of a number of similar backfilled sinkholes on the entire compartment. The model showed that the backfilling of single isolated sinkholes with gold tailings cannot adversely affect dolomite water quality with respect to uranium, irrespective of the uranium leachate concentration. However, the backfilling of clusters of sinkholes (comprising of 30 or more in a 1km² area) could result in the development of a uranium pollution plume over time. The more extensive the cluster, and the more concentrated the sinkholes in geographic extent, the greater the risk of pollution. Uranium leachability is the single most important factor in deciding the sustainability and hence acceptability of using gold tailings to backfill sinkholes. Provided that the uranium leachability is below 0.8 mg/l, the risk of pollution levels increasing above background by more than the SAWQ guideline level of 0.07mg/l is insignificant. The WHO guideline value of 0.002mg/l U has a higher risk of being exceeded.

The physical stability of backfilled sinkholes was determined to evaluate the sustainability of the current backfill practices and identify those factors that should be considered in the design and method of backfilling to reduce the risk of re-activation of backfilled sinkholes. Backfilling of sinkholes with purely non-cohesive materials poses a significant safety risk to humans due to the risk of sudden subsidence, caused by reactivation of the sinkhole. Backfilling of sinkholes with a cohesive material such as clay or cement-modified gold tailings material may significantly reduce the risk of occurrence of subsidence or re-activation. Backfilling with natural material from borrow areas in close proximity to sinkholes has the disadvantage of depleting the surrounding area of soil and also increasing the risk of sinkhole formation in the borrow area as a direct result of changed drainage conditions.

A legal review showed that the practice of backfilling sinkholes with tailings or mine waste rock is not in compliance with the law. The issue is however complex as a result of historic agreements between the Government and the mining industry and past decisions and precedents. Sinkholes will have to be secured for the safety of the public and structures in the close proximity to sinkholes. Furthermore since open sinkholes are associated with a significant risk of illegal dumping, backfilling of sinkholes appears a logical and appropriate solution. Further consideration to resolve the legality of the backfilling practice will, however, be required should mine waste materials be used in future for this purpose.

Cost: R440 000
Term: 2000-2002

PCR-based markers for identification of toxic cyanobacteria
Department of Genetics and the Forestry and Agriculture Biotechnology Institute (FABI), University of Pretoria
No 1502

The quality of many water sources in South Africa is declining. The decline is primarily as a result of eutrophication and pollution by trace metals. Cyanobacterial blooms do not only cause a health risk to both animals and humans, but may also result in other problems for suppliers and users of potable water. The increasing occurrence of toxic Microcystis aeruginosa blooms in major water resources makes identification and prediction of these toxic blooms very important. The research will contribute to the development of techniques that will aid in the rapid identification of toxic cyanobacterial strains and in assessing the potential toxicity of the strains. The objectives are to:

- Assess the genetic diversity of a wide variety of geographically unrelated strains of Microcystis aeruginosa collected from selected South African dams (e.g. Gauteng and North West Province).
- Develop an unequivocal identification system for toxigenic and bloom-forming genus Microcystis with the objective to manage cyanobacterial blooms by ensuring early detection of toxic strains.
- Correlate the observed fingerprint obtained using the toxin-producing mcyB gene to toxin levels measured in the specific strains.

Cost: R668 000
Term: 2004-2007

The determination of annual phosphorus loading limits and land-use-based phosphorus loading models for 30 key South African dams in relation to their present and likely future trophic status
W Harding (Private Consultant)
No 1687

The point of departure in eutrophication assessments is to determine the relationship between the levels of nutrient loading, in particular phosphorus, and the in-lake condition. A number of simple relationships exist for predicting in-lake phosphorus conditions based on hydro-morphological data and catchment land use. This project aimed to assess the relevance of such screening-level assessments across a wide range of South African impoundment types by testing a suite of models across a set of 30 dams.

Although unforeseen data limitations reduced the modelling set by 17, the aims were achieved for the remaining 13. The approach proved to be workable notwithstanding the identified need for a greater level of primary data sourcing and processing. As such the approach provides a means whereby impoundments and their catchments can be screened for their trophic status, sources of nutrient loading in relation to land-use, and Best Management Practices allocated accordingly.

This project has used flushing-corrected, annual time-step phosphorus models to analyse the conditions in a set of South African dams. Nutrient loadings to each dam were determined using a trial set of phosphorus export coefficients allocated to land-use practices. Model relevance (accuracy) was determined by comparing predicted vs. observed in-lake phosphorus concentrations. Models calibrated in this fashion allow for a desired total phosphorus load to be determined by reducing the loading to the point where the model output approximates the assumed 55 µg ℓ-1 TP phosphorus boundary concentration. While this approach has proved to be workable it remains subject to data constraints and verification of the relevance of the export coefficients used. Notwithstanding this the approach was used to determine Target Median Annual Phosphorus Loads (TMAPLs) for the dams in the test set.

No one model was found to apply to all of the dams that could be modelled. However, the Walker Reservoir Model, previously used for the Nutrient Enrichment Assessment Protocol (NEAP), again appeared to have strong relevance for South African conditions, i.e. for impoundments with relatively short (< 2-3 years) water retention times. As with the findings of previous studies the Combined OECD model was found to be generally applicable. The data constraints experienced in this project preclude reaching a definitive conclusion on model relevance and the re-calibration of any particular relationship for South African use.

All of the dams in the test set were in the eutrophic to hypertrophic range, with median annual in-lake phosphorus concentrations ranging from 31 to 626 µg TP/L. Targeted load reductions were found to be high, ranging from 25 to 96% of current loadings; 8 of the 13 dams evidenced load reduction requirements in excess of 50%, and 5 of these greater than 75%. These data indicate the severity of the eutrophication problems being experienced by these waters. The dams in the test set could be divided into three types, those dominated by urban sources of nutrient loading, those dominated by dry-land and/or undeveloped land use, and a mix of the two. In the cases of urban land-use dominance the primary source of nutrient enrichment is assumed to be treated wastewater effluents high in phosphorus content. Such sources are further deemed to be more suited to rapid nutrient attenuation (process upgrades), although not without significant cost implications, than are the more diffuse sources associated with dry-land and non-irrigated agricultural practices within the catchment.

Cost: R243 750
Term: 2006-2007

Production of microcystin standards and evaluation of cyanobacterial hepatotoxin quantification methods and their relative suitability for screening and quantification
Nelson Mandela Metropolitan University (NMMU)
No 1695

In the absence of a comprehensive survey of South African cyanobacteria that encompasses both distribution and diversity, no understanding of the dissemination and prevalence of toxic cyanobacteria is possible. The absence of a complete culture collection based on such a survey also precludes any general geographically or taxonomically representative analysis of South African cyanobacteria for any purpose. Additionally, expertise on the identification of cyanobacteria is extremely limited in South Africa and the development of a routine molecular identification facility coupled with and based on the molecular identification of culture collection material, would serve as a source of reference material for both training and cross referencing purposes.

One of the other major hurdles in cyanobacterial research and the management of cyanobacterial events, such as toxic blooms, is the continuing difficulty in obtaining commercial reference material for microcystins. The inconsistency in supply of microcystin standards for both identification of variants and quantification of toxins in water is compounded by the limited number of variants that are commercially available. Standards can take several months to obtain and some variants currently cost in excess of R25 000/mg.

General screening for microcystins in water supplies is commonly undertaken by commercial ELISA kits. No evaluation of these kits in terms of comparison with other existing screening and analytical methods has been undertaken with purely novel isolates of unknown hepatotoxin content. Anecdotal evidence suggests false positives for both ELISA and protein phosphatase inhibition (PPi) assays but a comparison of these methods would require a study of efficiency of variant detection and certain variants are not commercially available. Additionally, no laboratory in the country currently performs HPLC, ELISA and PPi, and can do so on molecularly identified taxonomically diverse uni-algal South African isolates.

This project was therefore intended to initiate the development of a culture collection and set in place the methods and facilities to address the remaining fundamental issues for future research to:

- Initiate the creation of a geographically and taxonomically representative cyanobacterial culture collection
- Establish full characterisation protocols
- Optimize the laboratory scale production of microcystin standards
- Evaluate current microcystin screening.

The defined primary objectives were achieved. Specifically, a taxonomically and geographically representative culture collection of South African cyanobacteria was established. Characterisation of uni-algal cultures and production of axenic cultures as well as complete phylogenetic analysis has been started and is an ongoing project (**WRC K5/1719**). Additionally, laboratory scale microcystin standard production was optimised and microcystin screening methods were evaluated. Evaluation of screening method efficiency for different microcystin variants was not achieved because to date no isolate has been identified that produces sufficient quantities of toxin other than microcystin-LR. Thus laboratory scale production of variants other than microcystin-LR has not been done.

To date 368 uni-algal cultures are in the collection, including four axenic cultures. Cultures are in various stages of characterisation and the information is currently available on an internal web-based database. Initiation of phylogenetic analysis using phase one of the sampling regime (Eastern Cape) yielded 16S rRNA gene sequence data for over 30 isolates suitable for analysis. Phylogenetic and phylogeographic analysis revealed reasonable genetic diversity but no geographic basis for the diversity. This suggests transfer of cultures between water bodies. Water scheme transfers were investigated but no downstream similarity could be detected. Increased resolution by sequencing of additional genes and genomic methods is indicated and this is currently being undertaken as is the continued analysis of isolated strains.

Protein phosphatase inhibition is not recommended for screening of water samples or isolated cultured strains, for the presence of microcystins or nodularin. The method is suitable for determining relative abundance of the toxin in a given strain where the method is optimised for that purpose. ELISA offers increased sensitivity for multiple variants and as such is a suitable water screening method which has been validated and verified and is currently in use. HPLC-PDA or HPLC-MS remains the industry standard and should be encouraged as the primary analytical method. Where raw water samples show positive results for ELISA, solid phase extraction of a sufficient volume should be undertaken prior to

HPLC-PDA to ensure adequate concentrations given the possibility of multiple variants

Ongoing maintenance and expansion of the culture collection has already been ensured by the WRC via NMMU where the culture collection is housed. Duplication of the culture collection has been started and duplicate cultures will be maintained at NWU (Potchefstroom) where further characterisation will also take place.

Full phylogenetic characterisation will also take place as a function of **WRC Project No 1719** and screening for both hepatotoxins and neurotoxins is ongoing. The creation of an online database as part of a central communications and data-sharing portal is essential for the full benefit of the culture collection to be realised and the creation of this facility has been started

Cost: R250 000
Term: 2006-2007

Programme 3: Pollution of surface water

Cyanobacteria programme: Investigation into toxin blooms and toxin promotion
Consortium members: PU for CHE; University of Port Elizabeth; Technikon Pretoria
No 1401 (b; c)

1401 (b)

Since many genera of freshwater cyanobacteria are capable of production of hepatotoxins, increase in the frequency and severity of bloom events poses a problem for potable water supply in that classical treatment methods result in cell lysis and release of these toxins. An understanding of the environmental conditions that modulate toxin production would therefore be beneficial to the management of potable water supplies. Definition of the primary parameters and a model of the mechanism of modulation of toxin production would further facilitate management and treatment.

The primary objective of this work was to determine the modulatory role of environmental orthophosphate and nitrate levels on microcystin production by the dominant microcystin producing genus in South African freshwater impoundments and to develop a model to describe the cellular mechanisms by which these environmental parameters modulate microcystin content.
The co-modulatory effect of environmental phosphorus was investigated because of the role of cellular phosphorus in photosynthetic carbon fixation, and the resulting effects on cellular C:N ratios and on nitrogen assimilation. The modulatory effects of carbon fixation: nitrogen uptake and cellular C:N ratios were also investigated in the absence of variation of growth rate so as to relate environmental N:P ratios to cellular activities. In order to further clarify any modulatory effects of these environmental variables, potential regulatory mechanisms were investigated. Specifically, the potential role of NtcA (a cellular nitrogen regulator) and the levels of nitrogen assimilation products and carbon precursors were studied so as to determine the cellular status of these constituents under environmental conditions leading to increased microcystin production, thereby attempting to elucidate the potential mechanisms by which the relevant environmental factors enhanced microcystin production.

Specific growth rates and protein and microcystin content of *M. aeruginosa* PCC7806 and M. aeruginosa UV027 were determined under non-limiting batch culture conditions for a range of medium nitrogen and phosphorus atomic ratios (N:P). Both strains exhibited a similar optimal medium N:P ratio for increased cellular microcystin levels. Additionally, total cellular protein content and intracellular microcystin content were significantly correlated. Microcystin and protein content increased considerably as the maximum specific growth rate for the experimental conditions was reached. The correlation between cellular protein and microcystin content and their relative increase with increasing specific growth rate occurred within defined ranges of medium N:P ratios. This suggests a close association between microcystin production and N:P ratio dependant assimilation of nitrogen, and resulting total cellular protein levels, which may be further modulated by specific growth rate.

Microcystis aeruginosa PCC7806 was grown in continuous culture with varying medium nitrate concentrations and sampled at steady states for analysis of cell numbers, microcystin content, cellular N and P, residual medium nutrient concentrations and carbon fixation rates. Cellular microcystin quotas showed significant positive correlation with both nitrate uptake and cellular nitrogen content, and were negatively correlated with carbon fixation rates, phosphate uptake, and cellular phosphorus. Thus the ratios of nitrate uptake to phosphate uptake, cellular N to cellular P, and nitrate uptake to carbon fixation were positively correlated to cellular microcystin. Microcystin quotas increased 10 fold between the lowest and highest steady state values. Contrary to what was previously reported, cellular microcystin content is therefore controlled to a significant extent by variables other than growth rate, with nitrogen being the most significant modulator. Batch culture in BG11 under identical conditions yielded increased microcystin when nitrogen uptake rate was relatively higher than growth rate, confirming the importance of nitrogen uptake in the modulation of microcystin content for a specific growth rate.

In conclusion, this work shows that the primary environmental modulators of MCYST production by Microcystis that are suitable for simple measurement, and use in predictive models, are environmental nitrogen and phosphorus and growth rate. However, given the complexity of the regulation of microcystin production and the strain variation in toxin production, it does not seem likely that a single general model will emerge that allows accurate long-term prediction of toxin levels unless accurate nutrient loading and PAR forecasts are possible. Despite this, reasonably accurate short- term prediction does seem possible, as does a general prediction on whether toxin levels will increase or decrease over periods possibly as long as one month. Work currently in progress includes the validation and refinement of these types of models on fed batch cultures of various strains and communities. Artificial neural network models also appear to hold some promise and should be further investigated. This work clearly shows the primary environmental modulators that should constitute the input nodes of such models and therefore substantially adds to the current knowledge base on predictive modelling of microcystin production. Similarly, the models presented here are the first reported models of toxin production based on environmental variables and as such constitute a major advancement in both the understanding of the regulation of microcystin production and the approach to both structured and a-posteri modelling of toxin production by *M. aeruginosa*.

Future work should be aimed at refining the model by large-scale validation in fed batch reactors and inclusion of additional environmental parameters. Ultimately the model should be validated on a suitable impoundment and refined for use on that specific water body so as to evaluate the predictive potential of microcystin modelling based on nutrient loading.

1401 (c)

Cyanobacteria are a group of extraordinarily diverse Gram-negative prokaryotes. Problems may occur as a result of algal overgrowth and the production of toxins. This species periodically blooms in Hartbeespoort Dam, a popular recreational dam and a source of domestic and irrigation water in North West Province. Consequently, there was a need to conduct a study to assess the appearance pattern and persistence of the *Microcystis aeruginosa* in the dam. The review examines numerous aspects that influence cyanobacterial growth in Hartbeespoort Dam, their persistence and various options that have been used to prevent and control the bloom. Critical among them include complex and dynamic relationships between physical, chemical and biological factors such as water temperature, pH, and nutrient availability (nitrogen, phosphorus, iron).

Eutrophication problems, which often results from increased anthropogenic activities has been widely accepted as the main problem in Hartbeespoort Dam. The nutrients are continuously generated in the catchment areas draining into the dam and the load from Jukskei/Crocodile rivers.

The primary aim was to investigate environmental factors that affect the occurrence, persistence and bloom formation of phytoplankton species with particular emphasis on the *Microcystis aeruginosa* in the dam.

Water and sediment samples for algal identification and quantification and for the determination of selected chemical water quality parameters such as, nitrates, phosphates, sulphates and metals were collected fortnightly. The study also retraced past data on physical and chemical quality parameters. Statistical t-test analyses were then conducted on the observed values and past data to determine significant differences that might have occurred over the years.

Results showed that Microcystis aeruginosa consistently dominated the impoundment at bloom levels during summer months. Other algal species such as *Pseudanabaena* and *Oscillatoria* spp. often associated with the *Microcystis* colonies and the planktonic diatom *Melosira granulata* var. *angustissima* were also observed. These species were more abundant in water samples than in the sediment samples throughout the season due to the favourable physical conditions such as temperature and light penetration required for photosynthesis in the upper water surface. However, 4 times more Microcystis aeruginosa colonies were identified in the sediment samples during the winter months than in late summer of 2003. This could be due to over-wintering behaviour. More so, unlike in the previous years (1980s and 1990s), *Microcystis aeruginosa* never disappeared in winter months from the water column for 3 consecutive years of study after the turnover of the dam.

The average levels of basic water parameters have remained fairly the same except significant changes in the levels of sulphate (1 096 µg/L), pH (8.35) and dissolved nitrates as NO_3-NO_2 (51.94 µg/L) for this study and 1 680 µg/L, 8.56 and 71.25 µg/L for previous studies respectively. However, values obtained in this study for the period of 2003 and 2004, also revealed increased Kjeldahl nitrogen (1961 µg/L) and total phosphorus, PO_4-TOT (73 µg/L) in 2003 compared to 1 155 µg/L and 48 µg/L in 2004 respectively. The surface water temperatures were also higher in 2003. Minimum temperatures increased from 9 to 13°C and maximum from 24 to 27°C for winter and summer periods respectively.

The study concluded that changes in phosphate, nitrate and temperature during the year 2003 provided favourable environmental factors for the cyanobacterial bloom observed in the dam. These could explain the reasons for 2003 and early 2004 unacceptable high bloom season in the dam.

This triggers an immediate warning sign based on risk assessment and allows relevant information to be processed to the stakeholders timeously. At the same time, it prepares the relevant authorities' task with both preventative and treatment options to begin preparing early enough to combat massive blooms and public protest that this dam has attracted over the decades.

Cost: R630 000
Term: 2002-2005

Programme 4: Low flows and streamflow reduction activities

An investigation of Jatropha curcas: A case study
CSIR
No 1497

Recent business initiatives have proposed the introduction of the so-called 'wonder-crop' exotic species for large-scale planting in South Africa. Specifically, *Jatropha curcas (J. curcas)* has been identified for introduction in several locations in the country. The plant has potential as a source of bio-fuels. The motivations behind these initiatives have been the laudable themes of poverty alleviation, job creation and business development. However, questions around the potential hydrological and ecological effects of the associated land-use changes remain unanswered due to a lack of information. Due to the significant area being proposed for planting *J. curcas* and other species, DWAF (Sub-directorate: Streamflow Reduction Allocations) has drafted a discussion paper proposing that all such species be declared streamflow reduction activities (SFRAs).

This study sought to investigate the water use of *J. curcas* in comparison with the natural vegetation that it will replace when planted for commercial use. Other study objectives were to:

- Develop predictive capability with respect to the impacts of large-scale planting of *J. curcas* on water resources through hydrological process studies and modelling using appropriate techniques
- Provide information regarding the biophysical requirements of *J. curcas* and produce maps through an ARC-View GIS modelling framework
- Gauge the perceptions and levels of understanding of SFRA processes and licensing amongst users of *J. curcas*
- Provide recommendations to the WRC, DWAF, the SFRA licensing committee and other stakeholders with regards to potential SFRA declaration and regulation of *J. curcas*.

In this study several *J. curcas* case studies were investigated through literature research, field measurements and computer-based modelling. The main technique in the field measurement was the heat pulse velocity (HPV) technique for measurement sap flow in plant stems and then converting this flow to water uptake by plants.

The *J. curcas* plants were observed to be very conservative water users when compared to natural vegetation. A complete winter dormancy, where no water intake by plants was observed took place in all the *J. curcas* plants investigated. Weather and soils water monitoring activities were undertaken to support the plant water uptake measurements. The simulations used the models, FA056, WAVES and SWB. The models relied on additional measurements to determine the variables in the equations used such as the Penman-Monteith in the FAO56 model which became the preferred simulation technique in this study. The simulation was useful in predicting the plant water use in larger catchments and in extrapolating the findings to other unmeasured catchments.

This research concluded that the *J. curcas* water use does not exceed that of natural vegetations that it might replace if planted for commercial use. From this evidence, *J. curcas* cannot be recommended for declaration as a streamflow reduction activity. The study also observed that there was a very low level of understanding of the plant. The study suggested that several trial plots using plants of different provenances should be established in different parts of the country to carry out investigations of water use, dormancy, growth and productivity under various conditions. Of importance to commercial plantation of *J. curcas* will be the economic assessments of the commercial plantations in various regions of the country especially to verify the observation made in this study that this plant can only be viably planted in relatively high rainfall areas which exceed 800 mm per year.

Cost: R750 000
Term: 2004-2007

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Decision support for IWRM at catchment and WMA level

Approval and licensing of groundwater development and use
Parsons and Associates
No 1510

The overall objective of the project was to identify legal requirements for authorising groundwater development and use in South Africa, and to develop a *Groundwater Licensing Guide* or decision-support

system that will allow officials, applicants and the general public to ascertain information that the officials require to assess applications to develop and use groundwater. Specific goals included:

- Development of workable definition for the term 'bulk water supply', an activity for which an EIA was required
- Review the general authorisations, as applied by DWAF to groundwater
- Review DWAF licence information requirements and licensing procedures
- Review EIA Regulations applicable to groundwater
- Develop a decision-support system that will allow users to ascertain information officials require to assess applications to develop and use groundwater
- Develop a standardised code of practice / standard operating procedure in order that as little environmental damage as is practically possible results from exploration drilling and pumping tests
- Document the results of the research and prepare a users manual.

It is expected that these guidelines will have to be periodically revised, to take into account changes to legislation and regulations. Since the term 'bulk water supply' is no longer used as a criterion for initiating an EIA in terms of the EIA Regulations, the need for this project to develop a workable definition of the term fell away.

To achieve sustainable groundwater use and protection, effective and efficient authorisation processes for developing and using groundwater are required. These processes should be fair, reasonable and just, result in a consistent outcome and not create an administrative burden. It is argued that present application procedures fail the above criteria and restrict groundwater use unnecessarily. In part, this is due to new and untested legislation driving the authorisation processes, the duplication of authorisation required by the NWA and NEMA and a lack of clear and consistent policy pertaining to specific aspects of the legislation (e.g. reasonable domestic use, using a single borehole to supply water to multiple properties). The lack of effective cooperative governance and a single lead authority to manage authorisation of the development and use of groundwater compound this. This guide aims to provide a reasonable framework for the application procedures for the development and use of groundwater, taking into account the often overlapping legal requirements of the National Water Act and the National Environmental Management Act. The NEMA sets out a range of principles that are to be applied by all organs of state when taking decisions that significantly affect the environment.

Cost: R390 000
Term: 2004-2007

Industry-government partnerships for the development of sector-based standards for the water environment
Karin Bowler Enterprises
No 1511

Negotiated Environmental Agreements (NEAs) offer alternatives in an effort to achieve environmental compliance. This legal mechanism which has recently been introduced into South Africa combines elements of regulation, self-regulation and cooperative relationships. The primary aim was to improve dialogue between diverse stakeholders and also with government to encourage change in traditionally reactive paradigms towards environmentally-focused regulation. Internationally, all NEAs focus on setting objectives above the legal requirements; in South Africa, this principle is contained in section 35 of the National Management Act 107 of 1998) in the form of Environmental Management Cooperation Agreements (EMCAs).

The intention of this research project was to determine whether section 35 EMCAs or other forms of NEAs would serve as effective mechanisms to achieve environmental compliance in the water sector.

The process to establish an NEA for the South Africa Metal Finishing Industry in KwaZulu-Natal (MFI) formed the basis of this research. The National Water Act 36 of 1998) (NWA) and the Local Government: Municipal Systems Act 32 of 2000) (MSA) are the two laws relevant to this industry. Three interrelated components crystallised from the research process as the key findings and recommendations underlying the current status quo of NEAs.

The establishment of a municipal court should be a priority. Environmental justice can be promoted by educating magistrates on the financial and environmental implications of non-compliance. This system will relieve pressure on the Department of Justice by expediting municipality-related cases; numerous are water-sector related.

It is recommended that a 'feebate' be introduced. Companies can benefit from compliance (a financial rebate is offered.) The substantial penalty is issued for non-compliance (a 'fee' or a tax). The municipal court system will also present an opportunity to increase fines issued by the municipality.

The MFI perceives NEAs as a means for government to avoid being held responsible for effective enforcement. The MFI is concerned that self-regulation may be a mechanism by which unfair competition practices within the industry are implemented.

An NEA is a strong tool for cooperative relationships if properly structured. The MFI is encouraged to strengthen the industry's Code of Conduct to improve business and operational standards. Comments from the MFI indicate that an improvement in government capacity may contribute towards improving attitudes.

Existing water-related regulations are robust and should achieve environmental compliance. As such the legal form of an NEA, i.e. NEMA section 35 EMCAs specifically could be considered superfluous in the water sector. NEAs can potentially complement existing regulations and provide a mechanism for constructive dialogue within the water sector; this could in time mature into a platform to encourage the concept of co-regulation. However, lack of government capacity is undermining the existing regulatory framework and the potential for future NEAs. This has resulted in negative attitudes permeating government and the MFI. If extrapolated to other sectors the longer term implications do not augur well for economic sustainability for local government and industry

Cost: R400 000
Term: 2004-2006

Programme 4: Transboundary water resources

Implications of South Africa's trade policies for water policy and water resource management
University of Pretoria
No 1564

Following South Africa's transformation to democracy, the country has seen major shifts in virtually all policy fields, including water management and international trade, which are of relevance to this project. Much of South Africa is considered 'water stressed' (DWAF, 2004) and competition over water resources between water use sectors is likely to increase. At the same time South Africa has been re-integrated into the international trade system, in which it fully participates as a member of the World Trade Organisation (WTO). South Africa has to align its policy objectives with respect to water resources management and water services with its obligations from international trade law in a way that is most beneficial to the country and its people. The objectives of the project were therefore to:

- Identify options to harmonise policies and laws in the two fields of water management and trade, and to ensure the protection of domestic policy objectives in the light of obligations resulting from international trade agreements
- Recommend channels for improved communications between government departments to ensure optimal policy harmonisation.

As one of the outputs, the Strategic Review of the Implications of South Africa's Trade Policies for Water Policy and Water Resources Management provides an overview of the various linkages between water and trade issues. This represents a first step towards developing an understanding of the inter-connections between trade and both water resources management and water services provision. The strategic review also highlights that there is a need for greater cooperation between government departments on water/trade issues, particularly when it comes to trade negotiation strategy development.

The latter issue was addressed in a report highlighting possible channels for improved cooperation between government departments on water/trade issues. During this project it was proposed by the DTI that cooperation structures be established with DWAF in order to discuss water-related issues and take them into account in the Regional Industrial Development Strategy (RIDS) planning process currently underway. This suggestion was also supported by some of the DWAF representatives consulted. These cooperative structures could take the form of a permanent arrangement – or may be an ad hoc committee formed between the two departments specifically to provide input and exchange information on the RIDS.

Based on the linkages identified in the strategic review, the report includes a discussion paper that explores some of the most pertinent issues with the specific objective of highlighting possible misalignments between current South African water policy and obligations resulting from international trade agreements. The report points out where South African policy is, or could be in the future, at odds with international trade law provisions and proposes possible mitigation strategies.

Cost: R530 000
Term: 2005-2007

Programme 6: Integrated catchment management

Influence of spills and releases on the river morphology downstream of a selection of existing dam spillways
PD Naidoo Associates
No 1314

The construction of a dam and subsequent controlled flows through the dam spillway affect the downstream river geomorphology. There are a few general models that predict how a particular river is likely to respond once a dam is constructed. However, these models which originate from mostly alluvial river systems tend to be very inaccurate and generally incompatible with South African river characteristics. South African rivers are largely dominated by bedrock and mixed river channels.

This study investigated and provided contributions to the customisation and application of predictive methods for assessing the influence of the construction of new dams or of existing dams on river geomorphology. The study also investigated existing models and methods to establish the currently used principles and theories. Through the use of case studies in South Africa, this study developed recommendation on the use and development of predictive models for use in South African dam development assessments.

Five case studies of existing dams were investigated across the country. These were Tzaneen, Vaal, Pongolapoort, Wagendrift and Goedertrouw dams. The ratios of sediment transporting discharge before and after the dam were calculated and tabulated for each dam. Results were evaluated against the measured figures. The river geomorphological conditions before and after the dam construction were assessed. In most cases the dams were noted to be trapping most of the sediment content and drastically reducing sediment content in the river downstream of the dam. These effects stretched for several kilometres exceeding 30 km in most cases.

The need to expand the data available on river flows, sediment yield and channel changes was highlighted in the project. This will ensure that further research produce more accurate river geomorphological change prediction models that are readily applicable to South African conditions. Such river response prediction tools will be used in evaluating the impact of dam developments and developing mitigation structures.

Cost: R500 000
Term: 2002-2004

PCR-based markers for identification of toxic cyanobacteria
Department of Genetics and the Forestry and Agriculture Biotechnology Institute (FABI), University of Pretoria
No 1502

Toxic cyanobacteria found in eutrophic, municipal and residential water supplies produce lethal toxins, and domestic and wild animal deaths are caused by drinking water contaminated by these toxins. Among the species causing death of livestock, blooms of *Microcystis aeruginosa* are the most common in South Africa. More than 65 microcystins have been isolated to date and they are the most abundant cyanobacterial toxins.

Monitoring the quality of water destined to public supply includes identification of potentially toxic cyanobacteria and their population density. Existing diagnostic technology does not provide for ease of analysis, since it is either specific but laborious and need specialied expensive equipment (i.e. mouse bioassays, HPLC, MALDI-TOFF) or non-specific and reasonably priced (i.e. ELISA and PPI2A assays). The objectives of the study were to:

- Determine the genetic diversity and population structure in selected South African water reservoirs
- Determine the potential of using the *mcyB* gene sequence as a diagnostic tool in raw water to detect the presence of toxin-producing cyanobacterial spp. in South African water reservoirs.

To elucidate the genetic diversity of geographically unrelated *M. aeruginosa* strains, we applied amplified fragment length polymorphisms as a fingerprinting tool, as it has previously been shown to be efficient to discern between organisms on intra- and interspecies level. AFLP fragments have been used to unravel cryptic genetic variation for a wide range of taxa, which have previously been impossible to resolve with morphological characters. A combination of primers with two and three selective nucleotides on 23 *Microcystis aeruginosa* and outgroup axenic strains was used for this purpose.

To achieve the second objective, two main strategies were followed. Firstly, the use of insertions and deletions (indels) present in the *mcyB* gene sequence as a fingerprint was tested, i.e. diagnostic tool to recognise the presence of 'known' toxic strains in water reservoirs. And secondly, the use of nucleotide polymorphisms present in the *mcyB* gene sequence, with putative function in toxin production for association genetics and as a diagnostic tool was investigated.

The usefulness of AFLP that is based on the selective amplification of genomic restriction fragments by PCR was investigated to differentiate between geographically unrelated *Microcystis* strains. In total 23 strains were subjected to the AFLP fingerprinting. After analysis of the data on the basis of the average linkage method, known as the Unweighted Pair Group Method using Arithmetic averages (UPGMA), a dendrogram with 4 clusters was obtained.

The study provided evidence for the applicability of AFLP in cyanobacterial taxonomy, and furthermore clearly demonstrates the superior discriminative power of AFLP towards the differentiation of geographical unrelated *Microcystis aeruginosa* strains that belong to the same species.

The recent identification of the *mcy* genes in the production of microcystin synthetase for the first time provides an avenue to study microcystin production at a genetic level. This study used PCR based technologies (i.e. PCR and quantitative real-time PCR), ELISA and PP2A methods for detection of strains present and determination of their toxigenicity. The presence of the toxic cyanobacterial strains was confirmed through the use of molecular markers that detect the presence of some of the *mcy* genes in the *mcy* gene cluster that is able to synthesise microcystin toxins in *Microcystis* spp.

In the study it was shown that the population structure of *M. aeruginosa* strains from South Africa proved to be very diverse, and different from strains from other geographic regions (i.e. North America, Europe and Asia). It has also been found that polymerase chain reaction (PCR)-restriction fragment length polymorphisms (RFLPs) may be a cheap alternative for species and/or strain identification, provided that an array of enzymes are used to ensure proper identification. However, the combination of PCR and quantitative real time (qRT)-PCR proved superior in terms of accuracy, time and costs. In the study, it was shown that using the *mcyB* gene in PCR assays, applied directly to environmental samples provide a useful indicator of putative toxicity, since the genetic potential of a strain to produce microcystin is measured. The PCR-based assays detect toxigenic cells rather than toxins and require little sample preparation and modest capital costs. Detection of toxic *Microcystis aeruginosa* strains through molecular markers for microcystin may have great end use-potential in routine analysis of aquatic ecosystems. Thus, it may make water monitoring more feasible and allow the early application of corrective action before cyanobacterial blooms start to decompose or disintegrate. The PCR-based assay is effective at a level of 10 cells/ml and can indicate a possible toxic bloom well before the cell count reaches the action alert at a cell density of 2 000 cells/ml (National Health and Medical Research Council/Agriculture and Resource Management Council of Australia and New Zealand, 1996) and a high alert level of 20 000 cells/ml, where blooms may contain sufficient toxin to be of concern for human health.

Cost: R668 000
Term: 2004-2007

CURRENT

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

A strategy for future investigations of deep groundwater systems in South Africa
Directorate Geohydrology, DWAF
No 1237

Present knowledge of fractured-rock aquifers in Southern Africa is mainly restricted to the 'shallow' (i.e. upper 100 m) of the earth's surface, where the ubiquitous role of erosional unloading/weathering is an important factor controlling the occurrence of groundwater. There are, however, a number of key indicators pointing to the existence of deep groundwater systems within many of these hard-rock terrains, e.g. thermal springs and artesian boreholes. With the shift in emphasis of groundwater resource assessment from the localised to the catchment scale, there is a need to assess the role of deep groundwater systems in the hydrological cycle. Due to a lack of information on and the complexity of the deep groundwater flow system, as well as the requirement of a multidisciplinary approach, a strategy for conducting such research has to be formulated as a prerequisite to detailed investigations. The results of this research will provide guidelines to the groundwater community in terms of the conceptualisation, exploration and development of deep aquifer systems, and will also identify key areas for future research.

Estimated cost: R198 000
Expected term: 2001-2007

A synthesis of the hydrogeology of basement aquifers in Southern Africa: Research needs and priorities
Council for Geoscience
No 1418

Basement aquifers are found extensively in sub-Saharan Africa. The only viable water supply to many rural communities is located in these aquifer systems. To contribute to sustainable resource development, all knowledge about the attributes and dynamics of groundwater occurrence in basement aquifers needs to be consolidated. This is necessary to identify the research needs, gaps and priorities. This project aims to synthesise current knowledge relating to basement aquifers in Southern Africa. The output of the synthesis will lead to a research strategy that will address shortcomings in our knowledge base. This is a necessary project to guide future research in the hydrogeological domain.

Estimated cost: R564 430
Expected term: 2003-2004

A catchment management strategy for the Kat River
Kat River Valley Water Users Association
No 1496

For the past 6 years, a process of community education and capacity building has been pursued by the communities in the catchment, aided by the Geography Department at Rhodes University. This process has resulted in the establishment of a Water Users Association (the Kat River Valley Water Users Association – KRVWUA). It, therefore, offers the opportunity on a pilot scale to develop and apply methods of establishing a cooperative catchment management strategy, including water allocations, the Reserve requirements and Resource Quality Objectives, and a monitoring programme. The objectives are to:

- Continue to develop the socio-economic capacity of the community of the KRV
- Establish cooperative governance of the resources of the Kat River between DWAF, the KRVWUA and the communities of the catchment, within the context of the Fish Keiskamma WMA
- Establish the criteria for acceptance by DWAF of the allocation schedule and the catchment management strategy
- Undertake a yield analysis to establish the water yield that can be reliably provided by the Kat River
- Assess the Reserve for the Kat River
- Develop RQOs for the Kat River
- Establish existing lawful use of the water resources of the Kat River
- Reach agreement among the WUA members on a water allocation schedule for license applications
- Establish strategic and contingency water requirements for the Kat River
- Establish the downstream water requirements of the users of the Great Fish River, into which the Kat River flows
- Design and initiate a monitoring programme that will assess the various water uses, Reserve flows and water quality, and the resulting state of the river.

Estimated cost: R2 100 000
Expected term: 2004-2007

Refining tools for evaporation monitoring in support of water resource management
CSIR
No 1567

Evaporation, after precipitation, is the largest component of the hydrological cycle at the land surface. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the

transpiration of plants. There are many compelling water-resource related reasons (among them demands created by recent water legislation) for being able to measure/estimate and monitor evaporation with sufficient accuracy and precision. While many potentially suitable techniques and methods exist, there is a lack of knowledge regarding their appropriate use and capacity in applying them. Consequently, this project will aim to:

- Classify and characterise land uses/units and water-resource management applications for which evaporation measurements/estimates are needed
- Assess accuracy and precision requirements relating to evaporation measurement/estimation for various water-resource management applications
- Assess appropriateness of evaporation measurement/estimation techniques for addressing a range of key water-resource management needs
- Develop guidelines for the complementary use of measurement and estimation techniques
- Develop/refine evaporation measurement/estimation techniques, where necessary, for key water-resource management applications
- Establish a sound basis for capacity building and skills development relating to evaporation measurement and estimation.

Estimated cost: R1 600 000
Expected term: 2005-2008

Remote sensing as a tool to determine the legal compliance of surface and groundwater users in catchments
Council for Geoscience/University of Cape Town GEOSS
No 1690

Since South Africa is such a water-scarce country, it is important for managers to have accurate information of all aspects of water resource management. This includes knowledge of the level of compliance of water users to water use licence legislation. In the Berg River catchment for example, compliance to water use legislation is checked by DWAF on a case-by-case basis. This is a tedious and time-consuming procedure. Remote sensing can be used to detect and map past and current water use. This can be compared to current water use licenses in the WARMS database. The aims of the project are therefore to:

- Use remote sensing to identify small dams in catchment areas of South Africa
- Establish the volume of water stored in small dams in selected catchments
- Use remote sensing and GIS to identify the illegal extraction of water from rivers
- Use remote sensing to identify potential groundwater resources
- Identify if groundwater is being used as resource rather than dams within the same area
- Quantify groundwater use based on identifiable agriculture
- Use remote sensing and GIS to identify legal compliance of groundwater users in selected catchments
- Develop a methodology whereby water use compliance can be ascertained for any catchment in South Africa whether groundwater- or surface water-driven.

Estimated cost: R1 259 600
Expected term: 2006-2009

Programme 2: Surface water/groundwater hydrology

Development of a user-friendly model for assessing the impact of waste discharge applications on downstream water quality
Stewart Scott (CE) Water Quality
No 1212

Successful catchment management from a water quality perspective, requires inter alia an intelligent representation (modelling system) of the catchment which describes present water quality and which can be used to predict the effect that proposed new or modified impacts will have on water quality at specific points. Options that need to be incorporated in such a modelling system include applications for new discharge points, increased discharges or altered permit conditions. It is also necessary to assess the impact of current and projected water use and alternatives for managing water quality. This points to the need for a simple but robust technology that can be used to rapidly assess the impacts of applications to discharge waste and the effect of proposed management options. The purpose of this project is to develop such a tool that will not replace the more complex models, but could rather be used to sift options to determine if more complex models need to be applied. The proposed tool could also serve to standardise the approach taken by CMAs in evaluating the initial results obtained by a large variety of organisations. It will be developed in cooperation with DWAF's Directorate of Water Quality Management and its Gauteng Region.

Estimated cost: R494 890
Expected term: 2001-2007

Flow conceptualisation and storage determination in TMG aquifer systems
Department of Earth Sciences, University of the Western Cape
No 1419

The TMG aquifer system is a regional aquifer considered to have potential to be a major resource for future water supply in the Western and Eastern Cape. This project addresses two key aspects, which are essential in order to manage TMG aquifers, i.e. conceptualisation of the groundwater flow system and determination of aquifer storage. The project will utilise a blend of fracture/analysis/remote sensing, field testing, use of hydrochemical/isotopic tracers and numerical modelling to address the research questions.

Estimated cost: R3 500 000
Expected term: 2003-2008

Protocols assessing the sustainability of springs
Maluti Water
No 1488

This project intends to develop a protocol for defining a spring-flow sustainability index. The development of a sustainability index would assist with water resource planning and result in security of water supplies to communities. The successful outcome of this project can result in innovative approaches to protect and manage springs (both from a water supply and protection perspective). The objectives are:

- The development of a protocol for defining a spring-flow sustainability index (i.e. a tool for assessing the sustainability of springs)
- Review all the factors that affect spring-flow
- Assess the value of isotopes in characterising the sustainability of springs, including testing the correlation of perennial and seasonal springs with the isotopic signature
- Develop a weighting system to assess the sustainability of spring-flow.

Estimated cost: R734 100
Expected term: 2004-2008

Water resources of South Africa, 2005 Study (WR2005)
SRK (CE) Inc.
No 1491

The *1990 Surface Water Resources of South Africa Study (WR90)* and its predecessors have played a major role in providing key hydrological information to water resource managers, planners, designers, researchers and decision makers throughout South Africa since the late sixties. The deliverables from the last nationwide water resource assessment in 1990, WR90, became essential tools for water resources management, planning and operational practitioners, researchers and decision makers. The 1990 study which basically focused on surface water resources has become less and less useful over the years as the water sector evolved with new legislation coming in (Water Act of 1998), changing land uses, improved knowledge and data, technological advances, and the need to answer new questions in a changing water sector. The

WR2005 study seeks to quantify and assess national water resources in an integrated manner that takes into account the new water environment and addresses the shortcomings of the previous nationwide studies. The objectives are to:

- Evaluate the WR90 project and its use. Critically review the outcomes of the WR90 project with regard to
  - o project implementation
  - o uses and users
  - o project impact on the water sector
  - o shortcomings and strengths
- Develop WR2005 project framework
- Develop WR2005 tools
- Develop WR2005 database
- Investigate and build a user support system for WR2005 products
- Document the project work and package products efficiently and cost effectively
- Introduce and build PDI capacity.

Estimated cost: R6 700 000
Expected term: 2004-2008

Flow conceptualisation, recharge and storativity determination in Karoo aquifers, with special emphasis on the Eastern Cape (Mzimvubu to Keiskamma Water Management Area)
SRK (CE)
No 1565

The Karoo rocks outcrop over almost three quarters of South Africa and act as a host for important groundwater resources. Hundreds of villages in the rural areas of the Eastern Cape and KwaZulu-Natal provinces obtain their water supplies from boreholes adjacent to or within the area of influence of dolerite dykes and sills, which have intruded the Karoo sediments. These conditions produce unique and complex hydrogeological systems, which complicates the development of groundwater. This project aims to:

- Conceptualise flow dynamics and groundwater flow paths
- Determine recharge-discharge and storativity and generate target maps for groundwater exploitation.

Estimated cost: R3 400 000
Expected term: 2005-2009

Towards improved estimates in water resources assessments using hyperspectral imagery to classify and map land-cover classes in Southern Africa (NS)
CSIR
No 1684

The quality of water resource research outputs, among other factors, depends on the accuracy and level of detail in available data resources. The finer spectral resolution of a hyperspectral imagery which allows for the detection of surface materials and their abundances, as well as inferences of biological and chemical processes, is set to improve local data resources. In this project, hyperspectral imagery will be used in the processing and analysis of remote sensing imagery to measure and characterise the spectral signatures of selected land-cover classes, to map selected and classified land-cover classes in study catchments as well as to contribute towards an envisaged spectral library for vegetation in Southern Africa.

Estimated cost: R643 700
Expected term: 2006-2008

The use of ^{222}Rn as a hydrological tracer in natural and polluted environments (NS)
CSIR
No 1685

^{222}Rn is a very soluble noble gas and because of its conservative nature has application as a hydrological tracer in fractured rock environments, providing insight into aquifer flow rates and groundwater residence times. Consequently, the aims of the study are to test whether ^{222}Rn:

- Is justified as a tool for use during baseflow studies in South Africa when compared to existing geochemical and isotopic parameters
- Concentrations vary with groundwater age, chemistry, depth or flow rate
- Concentrations vary with seasons
- Can be used to distinguish between different geological features or point sources of pollution
- Has application as a tool to optimise the positioning of passive treatment works, assess risk, or calculate financial liability at mine sites.

Estimated cost: R1 367 745
Expected term: 2006-2009

Basement aquifers in support of rural communities in Limpopo, North -West and Mpumalanga Provinces (with special emphasis on transboundary aquifer systems)
University of Pretoria
No 1693

The primary intent of this project is to develop an understanding of groundwater resources in crystalline metamorphic and igneous terrains. The focus areas are the basement aquifers occurring in the Limpopo and Mpumalanga Provinces, specifically the Limpopo and Luvuvhu/Letaba Water Management Areas. The main objectives of this project are:

- Based on stakeholder involvement (e.g. DWAF etc.) and previous studies (including areas that are experiencing water stress), identify regionally significant water-bearing structural features and geological domains for further detailed groundwater reconnaissance and exploration (to be based on utilising integrated groundwater exploration approaches viz. hydrocensus, tectonics and geodynamics analysis, strain analysis for field structural mapping, remote sensing, etc.)
- Conceptualise flow dynamics (interconnectivity, regional directional permeability and transmissivity) and flow paths (including dating and tracing of deep water) in the identified water-bearing structural features and geological domains
- Determine storage capacity and storage coefficients (and sustainability yield constraints) of the various geological domains and its reliability during droughts using appropriate investigative techniques.

Estimated cost: R3 400 000
Expected term: 2006-2010

Programme 3: Understanding and predicting hydro-climatic variability

A synthesis and encapsulation of hydrological research findings into a DSS for application and operational/planning level
School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal
No 1490

Hydrological operation and planning levels in South Africa are in the process of being updated in line with the requirements of the NWA of 1998 (NWA). The NWA requires the establishment of catchment management agencies (CMAs) to protect, conserve, manage and control water resources in water management areas (WMAs). Developments of tools to equip CMAs have occurred, with limited integration, such that the value of these developments to water managers has been very limited. This study seeks to develop a decision-support system (DSS) that will be useful for the operation and planning at CMA level. The development of the DSS will integrate existing research findings, data and available tools and will also make improvements to these tools. While national planning within DWAF has dealt primarily with relatively large scales (i.e. catchment and quaternary level) using monthly time steps, this study will focus on finer spatial and temporal resolution than was the case in the past. The finer resolution is targeted to deal with water resources at a range of scales varying from points of use to the whole WMA. Similarly, the planning aspect will handle a range of time scales varying from daily to annually.

The primary objective of this project is the development of a Hydrological Decision Support Framework (HDSF) which can incorporate relevant

and appropriate modelling algorithms/modules which are linked by a common flexible and extensible database and integrated with a GIS for use at a planning and operational level by CMAs at spatial scales ranging from point of use to the entire WMA and at temporal time scales of one day. The coarsest catchment scale at which the modelling algorithms/modules within the HDSF will operate in a lumped mode is at a quaternary catchment level and, in order to model the complexities of hydrological responses within a catchment, it is envisaged that the modules will be applied at sub-quaternary catchment scales. The HDSF should simplify and ensure maximum flexibility in system configurations, utilise GIS to generate system/module inputs and have interfaces suitable for water resource managers to interrogate the system. It is envisaged that the framework developed will be able to accommodate modules not utilised in this study. The HDSF is to include a spatio-temporal database populated with quality controlled data.

The purpose of the HDSF will ultimately be to support CMAs in planning and managing water resources under their jurisdiction and to provide tools to facilitate planning and scenario analyses. Although this will require a number of different functions to be performed, the main focus in this project will be the development of an HDSF to support CMAs in the assessment of water resources and the allocation of water use licences under the new requirements of the NWA of 1998. This will require designing the framework, integration of relevant modules, or adding functionality to existing modules, design of a generic and extensible database and GIS structures and the population of these with quality controlled data at both quaternary and sub-quaternary catchment scales. A suite of relevant simulation modules best suited to the requirements of CMAs will be selected for incorporation into the HDSF. The selection of modules will be finalised after a review of user needs has been performed, but it is anticipated that a physical-conceptual process based on hydrological modules, integrated so that system analyses can be performed, will be required for the assessment of water resources and the allocation of water-use licences. It is envisaged that the HDSF will be applied on selected catchments within two WMAs which will give the opportunity to assess and refine the HDSF.

A further objective of the project is to extend the capabilities of some of the modules so as to enable the assessment of water resources and the allocation of water-use licences at the level of CMAs as well as to consolidate and encapsulate existing relevant research findings into the selected simulation modules in order to refine the simulation of hydrological processes. Within the constraints of the budget and available resources, these could include an easy-to-use methodology to simulate dynamics in the catchment, refinements to hydrological processes, addition/refinement of selected water quality modules, refinements to cater for proposed new water allocation and management options such as fractional water allocation and capacity sharing / water banking, and inclusion of dam operating rules to meet IFR and other water demands. Where necessary, additions and refinements will be made to the selected modules to extend the HDSF such that it can be used operationally. These include 'ownership' of water in impoundments and near-real time operations with links to climate forecasting systems. An additional objective will be to provide user support and up-to-date user documentation for the HDSF and to assist users in the implementation of the HDSF. Thus this project will collaborate where possible with other WRC-funded research projects (e.g. **No 1318, No 1320 and No 1430)** as well as with solicited proposals currently under consideration **(KSA 1: Water resources of South Africa, 2005; KSA 1: Low flows and streamflow reduction activities; KSA 4: Standards and guidelines for improved efficiency of irrigation water use from dam wall releases to root zone application; KSA 4: Technology transfer and integrated implementation of water management models in commercial farming)** and with modelling efforts at DWAF (e.g. systems analysis) in order to reduce duplication of effort.

Estimated cost: R2 597 000
Expected term: 2004-2008

Programme 5: Climate change and hydro-climatic variability

A guideline for the selection of toxicity tests in support of the information requirements of the National Water Act
Division of Water, Environment and Forestry Technology, CSIR
No 1211

An important implication of the NWA is that the introduction of both source-directed controls and resource-directed measures aimed at improving water quality will be based on the effect of these measures on the resource. Biological toxicity tests are ideally suited to assess these effects for stressors. Toxicity assessments can be used to set the standards used in source-directed controls, or to elicit a site or situation-specific response to a stressor. A large number and variety of biological tests are available internationally for aquatic toxicity assessment. A range of toxicity tests has also been established for South African use. Most of the local tests are presently applied in hazard assessments to establish toxicity at the source level. However, in order to implement the requirements of the NWA, methodologies appropriate for resource-directed measures and source-directed controls are required, as well as knowledge on how methodologies for one application relate to the other. The purpose of this project is, therefore, to establish a guideline for the selection of toxicity tests that would support the information requirements of the NWA. This will be compiled in a user-friendly document that will facilitate the application of toxicity assessment in water resource management.

Estimated cost: R450 000
Expected term: 2001-2002

Review of research needs and priorities for water quality assessment studies and information systems
Umgeni Water
No 1424

Arising from the National Water Policy of 1997 (which can be termed 'executive policy') is a suite of new component or 'operational' policies, related to various aspects of the management, protection, development and use of water resources. Some very significant changes have occurred in the way in which water quality is managed, both from a resource point of view (through the resource-directed measures) and a source point of view (source-directed measures). Policy at the operational level has advanced in both these areas. In addition, the institutional landscape of water resource management, which includes the management of water resource quality (and water quality within that context) will change significantly in the short and medium term, as catchment management agencies and other local-level water management institutions begin to play progressively greater roles in everyday water resource management.

Water quality is often ignored in resource assessment. This project will provide a strategic framework for research investment by identifying research gaps and priorities. The project aims to:

- Review research needs and priorities for water quality assessment, with a focus on water quality assessment studies and water quality information systems, arising from recent South African water quality policy development and implementation initiatives associated with resource-directed measures as well as source-directed measures
- Provide strategic guidance to the WRC for future research in this area.

Estimated cost: R200 000
Expected term: 2004-2005

MOSMEPS (Model Output Statistics applied to multimodel ensemble long-range climate prediction)
South African Weather Service
No 1492

This project will combine single general circulation models (GCMs) into a multimodel ensemble since GCMs differ in their parameterisations and, therefore, differ in their performance under different conditions. Using a suite of several GCMs not only increases the effective ensemble size, it also leads to probabilistic simulations that are skilful over a greater portion of the region and a greater portion of the time series. Multimodel ensembles are nearly always better than any of the individual ensembles. The benefits from combining ensembles are a result of the inclusion of complementary predictive information since the scheme is able to extract useful information from the results of individual models from local regions where their skill is higher. The project seeks to assemble leading forecasting models and to put into place a scheme for using models operationally in a complementary way, and assess their skill in producing probabilistic ensemble climate forecasts. The objectives are to:

- Investigate the operational predictability of seasonal to inter-annual rainfall and its extremes over Southern Africa through the use of multimodel ensembles
- Investigate the operational predictability of seasonal to inter-annual occurrence of tropical cyclones over the south-western Indian Ocean through the use of multimodel ensembles
- Test different recalibration methods linking GCM-simulated large-scale fields to rainfall
- Assess if the recalibration is an improvement over raw GCM rainfall forecasts
- Test various multimodel ensemble combination schemes
- Set up an operational multimodel prediction system at the SAWS to the benefit of the end-users of seasonal forecast products.

Estimated cost: R436 000
Expected term: 2004-2008

Using enhanced knowledge of climate variability for the benefit of water resource management
University of Cape Town
No 1566

Research into climate variability over the past 15 years has enhanced knowledge substantially with regard to the Southern African region. Because of the sensitivity of water resources in the region to climate variability, it is imperative that this knowledge be utilised optimally for water resource management. Consequently, this project will focus on:

- Identifying the strengths and weaknesses in current climate prediction tools from the water resource management perspective
- Assessing whether recently gained knowledge of climate variability (including knowledge resulting from locally-conducted research) and new insights from current research on climate variability related to climate change can be used to improve tools, and/or the effectiveness with which tools can be used, by water resource managers
- Demonstrating beneficial use of best available tools or tools specifically improved for water resource management applications and transferring knowledge in this regard
- Filling crucial knowledge gaps which are known to still exist, in as far as this is possible in the short term
- Identifying longer-term research, capacity building and/or educational initiatives to enable water resource managers to derive maximum benefit from climate modelling and forecasting tools.

Estimated cost: R1 478 000
Expected term: 2005-2008

The role of antecedent conditions in determining rainfall characteristics during the early part of the rainfall season (NS)
University of Cape Town
No 1681

The early part of the rainfall season is a critical period for water resources in South Africa. Initial rainfall and its characteristics (frequency and intensity) determine the saturation of soils, contribution to runoff and associated reservoir storage levels as well as farmers' preparations for planting. It is the character of the climate and how it interacts with local and regional conditions such as vegetation, soils and the topography that largely determines soil moisture levels. This project will aim to:

- Understand the interactions of vegetation and soil moisture with the large-scale atmospheric circulation during the early part of the rainfall season
- Identify regions where characteristics of early seasonal rainfall may be influenced by vegetation and soil moisture and understand the implications of land-use change for the early season climate of the region.

Estimated cost: R1 642 600
Expected term: 2006-2010

Programme 6: Water resource quality management

GIS based assessment of non-point source pollution in Kuils-Eerste River catchments, Cape Town
University of Western Cape
No 1692

The water quality and hydrological character of the Kuils River and Eerste River in the Western Cape which discharge into the False Bay have been changed drastically by land uses in the catchment area. Major sources of pollution are the continuous effluent dischargers from the Macassar Sewage Works as well as the non-point source (NPS) pollution due to the present land-use practices in the Kuils-Eerste River catchment. The assessment and quantification of NPS pollutants in this area and others has always been a major challenge. This study will aim to provide techniques for assessing and quantifying NPS pollutants and developing intervention measures Kuils-Eerste River catchment. In addition, this project will also assess runoff water quality over different land-use types, extend the existing data on streamflow measurements and water chemistry of streamflow and other surface runoff water in the area, generate a GIS-based water quality hydrologic model (catchment loading model) and provide guidance for the mitigation of the water resource pollution in the Kuils-Eerste River system.

Estimated cost: R713 000
Expected term: 2006-2009

An investigation into the effects of atmospheric pollutants on surface water quality in the eastern regions of South Africa
University of KwaZulu-Natal
No 1697

South Africa possesses abundant sources of coal, found chiefly in Mpumalanga Province. This region therefore houses power generation facilities which supply the majority of the country's needs. The process of combustion of coal leads to the production of wastes which are discharged to the atmosphere, whence they are transported across the region by atmospheric circulation before being re-deposited on the land surface. Amongst the pollutants emitted by the burning of fossil fuels are oxides of nitrogen and sulphur (NOx and SOx). These compounds have for decades been associated with large-scale environmental degradation, (chiefly acidification of soils and water) in the first world. More recently their deleterious effects have been recognised as potential threats to ecosystems in other parts of the world, including the eastern regions of South Africa. The project therefore aims to:

- Investigate the deterioration of surface water quality in selected catchments of the eastern regions of South Africa over the past few

decades, due to the effects of atmospheric pollution

- Investigate deterioration of soil quality in selected catchments of the eastern regions of South Africa over the past decade and a half, due to the effects of atmospheric pollution
- Project, by means of modelling, future deterioration of soil and water quality in selected catchments of the eastern regions of South Africa under various management scenarios
- Illustrate the cost-benefit dynamics of managing pollution from atmospheric sources
- Ascertain the reliability of available estimates of atmospheric deposition.

Estimated cost: R1 435 300
Expected term: 2006-2009

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 1: Developing predictive tools and adaptive measures to global climate change

Secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change
University of Cape Town
No 1562

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function, with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R2 500 000
Expected term: 2005-2008

Programme 2: Human-induced impacts

An investigation into the impact of landfill leachate on the physical, chemical and microbiological quality of the Soutpan Stream and its immediate surroundings
Department of Chemistry, Technikon Northern Gauteng
No 1341

The Soutpan Stream runs past a very poorly managed landfill site which serves the local Soshanguve community. The landfill is used for dumping of domestic and industrial wastes. Visible leachate is observed on a regular basis running into the Soutpan Stream. The Soutpan Stream serves a huge informal settlement as sole water source and thus presents a health hazard. The community uses the water for household practices, gardening and for animals to drink.

This project aims to improve the situation and make the water and the landfill practices acceptable according to set guidelines. This will serve as an upliftment project for the community as it will make use of their experience and knowledge. The research aims to:

- Conduct an environmental inventory and audit of the study area
- Obtain information on how the landfill site is managed, the hydrogeological conditions, attenuating factors, weather patterns, volume and type of waste dumped, the volume and characteristics of leachate produced
- Investigate the direct and indirect physical, chemical and microbiological impacts and consequences over a defined range of temporal and spatial scales of the leachate generated at the poorly managed landfill site on the Soutpan Stream and its immediate surroundings
- Suggest measures which will help to minimise any adverse impacts on the environment and human health.

Estimated cost: R386 000
Expected term: 2002-2004

Persistent organic pollutants (POPs) in the environment
North-West University
No 1561

South Africa is a signatory to the Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research now needs to be taken further in order to:

- Assess with higher confidence the scale and significance of the occurrence of POPs in the water environment in South Africa, the potential short-term and long-term impacts on water resources and water-linked ecosystems and the associated threats to sustainability of water resources and water use
- Better identify and quantify the fate and effect of selected POPs in the water environment
- Guide and inform the development of appropriate policy and regulatory measures that will:
  - support implementation of the requirements of the Stockholm Convention
  - substantially contribute to the protection of water resources and water–linked ecosystems with regard to POPs.

Estimated cost: R1 500 000
Expected term: 2005-2008

Development of a model to assess the cost associated with eutrophication
The Institute of Natural Resources
No 1568

Eutrophication and its accompanying effects is one off the intractable symptoms of water pollution associated with modern society. It diminishes the quality of our water resources for many uses and costly treatment is often required to overcome its negative effects. In the prevention vs. cure debate, it is important not only to know the cost of prevention, but also the cost associated with eutrophication when it occurs at various levels, in order to justify often expensive preventative measures. Knowledge of the cost associated with eutrophication will also help in determining and justifying the introduction of waste discharge charges. Similar to a study that assessed the cost to users that can be associated with water salinity, a multidisciplinary team will conduct this project to determine the costs associated with eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000
Expected term: 2005-2008

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface water and groundwater
University of Pretoria
No 1686

The adverse effects of endocrine disrupting chemicals (EDCs) in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid

manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In SA no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal. In this study the presence/absence of veterinary drugs in the environment would be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources screened for estrogenic and anti-androgenic activity, using a battery of bio-assays.

Estimated cost: R1 900 000
Expected term: 2006-2009

Programme 3: Integrated flood and drought management

Soil moisture from satellites: Daily rainfall maps over RSA, for flash flood forecasting, drought monitoring, catchment management and agriculture
Pegram & Associates
No 1683

The amount of water in the soil acts as a vital switch between the atmosphere and the ground, governing many earth-bound water processes: infiltration, evapotranspiration, interflow and groundwater recharge. If accurate spatial estimates of SM over large areas were available, they would be useful in many applications in hydrology, meteorology and agriculture. A number of satellites, launched in the recent past have capabilities to measure variables for calculating countrywide SM at fairly high resolution. This project is expected to develop, and put in place, the scientific capacity to exploit the hardware, software and skill that exist in different international satellite agents. Other key project aims include:

- Developing a daily soil moisture map over Southern Africa at a resolution of 1 minute of arc and loading it onto the internet
- Ground validation for remote sensing using soil moisture estimates at probes deployed by SAWS
- Interpolation over Southern Africa of meteorological variables near ground level: temperature, pressure, humidity, wind speed and energy.

Estimated cost: R2 483 200
Expected term: 2006-1010

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

Importance of groundwater in the hydrological cycle and the relationship to surface water bodies
Department of Hydrology, University of Zululand
No 1168

Understanding the processes involved in groundwater-surface water interactions is becoming increasingly important for protecting the integrity of ecosystems. This project aims to develop models of typical groundwater-surface water processes in South Africa and also to establish compatible methods for estimating time series of surface and groundwater rates for comparative analyses.

Estimated cost: R770 000
Expected term: 2000-2007 (extended)

A multitracer study of the origins, systematics and hydrological linkages of high nitrate concentrations in Bochum District, Northern Province
Schonland Research Centre, University of the Witwatersrand
No 1328

In large tracts of the Northern Province with millions of inhabitants who rely almost exclusively on groundwater supplies, high nitrate values are reported. High nitrate concentrations in drinking water may lead to methemoglobinaemia, impairment of the blood to transport oxygen in infants, whilst sustained exposure to high nitrate levels may cause intestinal cancer in adults. The results of this study are intended to produce strategies and guidelines for the mitigation of high nitrate concentrations which, it is expected, will find direct application in the current investigation which logically can be extended into a region in which an enhanced understanding of the systematics of excessive nitrate levels in groundwater is a high priority.

Estimated cost: R300 000
Expected term: 2002-2003 (extended)

Land-use impacts on salinity in Western Cape waters
Department of Soil Science, University of Stellenbosch
No 1503

The importance of dry-land salinity on water resources has been recognised for quite some time. Its importance is especially visible in the dryer parts of the country and in Western Cape rivers. Earlier research attributed the mobilisation of salt to ploughing of land, which increases infiltration and accelerates the mobilisation of salts contained in the underlying geologic strata. Another potential mechanism is that changes in land use from extensive pastoral use to intensive cropping over the last century or more may have triggered the same process of salt decantation being experienced in Australia. As the salinisation of some Western Cape dams is intimately linked to salinity releases from agricultural land it is important to gain a better understanding of the mechanisms that are operative. The central aim of this project is to develop a thorough understanding of soil water and salinity dynamics, salt sources and salt storage in dry-land profile and hill-slope transects, as well as corresponding groundwater salinity dynamics. This understanding should inform future large-scale modelling and enable the development of land-use practices that would reduce/prevent degradation of land and water resources.

The central objective of this project is to develop a thorough understanding of water and salinity dynamics in the regolith (soil plus vadose zone) of a small dry-land catchment representative of semi-arid conditions in the Berg River basin. The perspective will include both salt sources and storage and groundwater fluxes and catchment runoff, in order to inform future large-scale modelling and to guide the development of land-use practices that would reduce the degradation of land and water resources.

Subsidiary objectives are to:

- Determine and map the spatial distribution of salts across the whole Berg River catchment
- Spatially relate salt distribution to salinity generating factors (soils and soil-forming processes, geology, climate, topography, vegetation and land-use) across the whole Berg River catchment
- Develop an improved understanding of how local tillage and other dry-land farming practices augment or reduce the mobilisation of salts
- Conduct mechanistic modelling of salinity dynamics
- Use the model to create small catchment-scale salt flux scenarios for various land-use and water-management practices that will serve to inform modelling of salt fluxes on a regional scale.

Estimated cost: R2 347 068
Expected term: 2004-2007

Novel silicone rubber integrative passive field sampler
School of Environmental Sciences/Department of Ecology and Resource Management, University of Venda
No 1504

Time-weighted average (TWA) passive field samplers provide vital information in ecological risk assessment of chemical pollutants. The passive field samplers quantify the freely dissolved pollutant in water that approximate the bio-available fraction in

longer exposure times. They therefore also give vital information on changes in pollutant level over time. However, not many passive field samplers are available and those that are available are mostly not very selective. They furthermore require additional clean-up steps before analysing the extracted samples. This project aims to develop, construct and test a simple and cheap TWA passive field sampler that will require no mechanical device and can be used in remote sites. The sampler will utilise silicone rubber in the form of a hollow fibre as absorbing medium. The inside of the hollow fibre will serve as the receiving phase and the outside as the donor phase. The pH of the solution in the receiving phase will be set such that target analytes are ionised and trapped. It is anticipated that this will result in very high enrichment factors over longer exposure periods. The developed sampler will be evaluated under laboratory conditions for its trapping efficiency for a range of pollutant groups as well as potential synergism and antagonism associated with trapping combinations of pollutant groups. The objectives are to:

- Develop a time-integrated sampling device based on silicone rubber for measurements of pesticide concentrations at environmental levels under field conditions
- Evaluate the efficiency of the sampling device for trapping representative examples of pesticides and other pollutant groups
- Determine the synergism and antagonism associated with trapping combinations of pollutant groups
- Evaluate the release of high concentrations during subsequent exposure to lower environmental concentrations.

Estimated cost: R250 000
Expected term: 2004-2007

Sampling and monitoring protocol for radioactive elements
University of the Western Cape
No 1694

The presence of radioactive constituents (uranium, thorium and associated daughter elements) in groundwater poses a health risk. Weathering and leaching of trace element-rich geological formations and also mining wastes result in high concentrations of these constituents in groundwater. The National Radioactive Monitoring Programme (NRMP) of DWAF aims to monitor radioactive elements on a national scale. The focus of this study is to support the NRMP by implementing investigations around impacted sites for local monitoring programmes. Specific objectives are to:

- Re-evaluate the results of earlier research findings on uranium speciation and the associated anomalies (i.e. anomalies in the aqueous environment) at the selected study area
- Apply recent advances to characterise flow regimes in fractured rock aquifer systems, with reference to 'tracing' the distribution of radioactive elements in fractured media
- Develop of local-scale sampling and monitoring protocol for radioactive elements in fractured rock formations
- Delineate a groundwater protection zone around a selected study area with respect to an unstressed system taking into account the hydraulics, behaviour of selected radio-active elements, relevant policy documents, etc.

Estimated cost: R1 500 00
Expected term: 2006-2009

Nitrogen dynamics in catchment landscapes cleared of alien vegetation and impacts on water quality
CSIR
No 1696

Extensive areas of land in South Africa are currently being cleared of invasive alien vegetation under the DWAF *Working for Water Programme*. Several of the invasive alien trees being targeted are legumes (e.g. Acacia spp. such as black wattle, rooikrans and Port Jackson willow), which fix nitrogen, thus a distinct risk that clearing alien vegetation may lead to nitrate contamination of groundwater and eutrophication of surface water bodies exists. The proposed study will be a systematic assessment, in two or three selected catchment areas in the Western Cape, of nitrogen stocks in soils under alien vegetation and nitrogen movement in soils, subsoils, groundwater and surface water after clearing. Nearby areas with natural vegetation will serve to provide baseline data. The project aims to:

- Quantify nitrogen accumulation in soils and sub-soils under invasive vegetation, using undisturbed natural vegetated areas as baseline
- Investigate the spatial distribution of nitrogen species (nitrate, ammonia, and organic nitrogen), within soil and subsoil profiles and across catchment landscapes, as well as surface water and groundwater
- Determine changes to the physical distribution and chemical speciation of nitrogen in catchment landscapes after clearing of alien vegetation and the impact on the quality of water resources.

Estimated cost: R845 000
Expected term: 2006-2008

Programme 2: Urban and rural water resource management

The history of Cape Town's river systems: Using hindsight to guide the management of urban river systems in South Africa
Southern Waters Ecological Research and Consulting
No 1691

Historical urban water resource issues, encountered problems and how they were resolved, changes in the whole water resource environment including physical changes to the riverine and catchment areas are documented in a number of archived municipal material. In addition, satellite images and aerial photographs have also captured changes over time. An analysis of past events, water resource problems, the interventions undertaken and the associated ecological, economical and social implications will enable the provision of meaningful guidance on the future management of urban rivers. This project will also aim to:

- Undertake a comprehensive review of the management of rivers in Cape Town in the 20th century
- Evaluate the options selected in the past to improve understanding of implications on social, ecological and economic costs and benefits
- Use the lessons learnt to inform a set of principles for future management of Cape Town's rivers in particular, and urban rivers in South Africa in general.

Estimated cost: R642 200
Expected term: 2006-2008

Programme 3: Integrated river flow and catchment hydraulics

Ecological and environmental impacts of large-scale groundwater development in TMG aquifer systems
CSIR / Umvoto
No 1327

There is currently a debate concerning the extent to which groundwater abstraction from TMG aquifers will lead to environmental impacts. This project aims to assess the dependency of aquatic and terrestrial TMG ecosystems on groundwater and predict impacts of groundwater abstraction. These ecosystems include wetlands, highland seeps, the riparian zone and spring discharge sites, amongst others. Specific objectives are:

- The development of predictive tools to assess the impact (or risk) of groundwater abstraction on the environment
- To improve our understanding of groundwater-dependent ecosystems (GDEs) in the TMG and the sensitivity to groundwater level fluctuations
- The use of innovative techniques to determine the impact of groundwater abstraction on the environment

- The development of indicators to monitor the effect of abstraction on sensitive ecosystems
- Coupling time series and spatial databases in order to ascertain the impacts of low flows (groundwater and surface water interaction) on the environmental system
- Improved understanding of the impact of changing low flows on freshwater ecology
- Improved understanding of the relationship between surface flow, event discharge from high-lying TMG unconfined aquifers and deep confined-aquifer discharge in maintaining wetlands or seeps
- Improved understanding of subsurface TMG discharge in maintaining coastal plain wetlands and vleis.

Estimated cost: R2 201 327
Expected term: 2002-2007 (extended)

An investigation and formulation of methods and guidelines for the licensing of SFRAs with particular reference to low flows
School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal
No 1428

Section 36 of the NWA of 1998 gives the Minister of Water Affairs and Forestry the powers to declare a land-based activity as a streamflow reduction activity (SFRA) if that activity is likely to significantly reduce the availability of water in a watercourse to the Reserve, to meet international obligations, or to other water users. While afforestation has so far been declared an SFR activity, scarcity of knowledge has been identified as a major constraint in this regulatory process. The available licensing methods have been noted to be too coarse and, besides spatial scales, have also failed to handle issues such as soil textures and varying temporal scales. Questions surrounding the licensing process, the basis of the methods in use, the future of SFRA licensing and the need to evaluate other land uses continue to build up. This study seeks to develop scientifically robust (generic too) and legally defensible methods of assessing low flow reductions and ultimately develop guidelines for the licensing of SFRAs. The objectives are:

- To re-analyse, and improve upon, conceptual modelling methods and input data utilised in **WRC Project No 1110 (Estimation of streamflow reductions resulting from commercial afforestation in SA)** and the reconsideration of methods used for the derivation of confidence limits from the above project, and the incorporation of these into the proposed guidelines
- Analyses of different flow components (quickflow, interflow, baseflow and groundwater discharge) to determine how these are affected by afforestation and by dry and wet cycles as well as the determination of the relative importance of the flow components between catchments and the impacts of afforestation on the flow components
- Through these analyses, and with input from related process study research, to improve the simulation of low-flows in the ACRU Agrohydrological Modelling System through improved conceptualisation of low- flow generation processes and the translation of these into model code
- To devise and implement a process whereby research and management needs are pursued in parallel in order to ensure optimal applicability and usability of the products of SFRA-related research
- To provide a link between researchers involved in hydrological process studies (e.g. **WRC Project No K8/577 (Weatherley catchment: Soil organic carbon and vegetation baseline study) and K5/1317 (The relationship between soil water regime and soil profile morphology in the Weatherley catchment, an afforestation area in the North-Eastern Cape)** of the effects of land-use change on low flows, and managers and other interested and affected parties involved in this field
- To refine the guidelines for dealing with scale and resolution in the quantification of SFRs developed by Ninham Shand and the University of Stellenbosch
- To provide guidelines for the declaration of additional SFRAs that may be declared in the context of recent DWAF discussions and their authorisation in the context of the above guidelines
- To develop and implement in DWAF national and regional offices, and existing CMAs, a decision support system and associated guidelines, to assist in hydrological assessments for the consideration of water use authorisations. These will form an SFRA component of the planned Water Allocation Toolkit, the components of which can be applied consistently across regions, are transparent in approach and are adaptable in that they can be upgraded or amended with minimum disruption
- To ensure the compatibility of Reserve determination methodologies and the results thereof with SFRA and other water use estimates and available hydrological information through consideration of specific months and daily flow records for various assurance of supply levels
- To test these products through the application of the guidelines in at least four catchment case studies
- To improve the research capacity in South Africa in the field of land-use hydrology and integrated water resource management and the skills of water resource managers involved in water-use licensing, particularly SFRAs.

Estimated cost: R3 800 000
Expected term: 2004-2007

The impact of deep-rooted trees on the hydrological balance of a small catchment in the KwaZulu-Natal midlands
CSIR
No 1682

Recent WRC studies and modelling of forestry water use have shown that our best estimates of tree water use, and in particular dry season water use are not within acceptable error margins. One of the main reasons is the inability of hydrological models to accurately simulate the deeper soil water processes. This project which will rely on field-based experimental work and computer modelling is expected to:

- Quantify the long-term effects of commercial forestry species on deep soil water profiles, streamflow and evaporation
- To investigate and describe environmental and soil water processes which allow for total evaporation to exceed the annual rainfall
- To provide a modelling framework for the catchment water balance to improve streamflow predictions and specifically low flows
- To extend and test the database of the catchment hydrological variables including data on tree root behaviour and its effect on soil water in deeper soil layers in modelling studies.

Estimated cost: R639 200
Expected term: 2006-2009

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Water resource management in rainwater harvesting (RwH): An integrated system
Source Strategic Focus (Pty) Ltd
No 1563

Rainwater harvesting (RwH), an old technology that dates back thousands of years, is gaining popularity in a new way. The global trend towards cheap and less ecologically disruptive water supply systems has tended to favour the development and application of cheap, environmentally friendly and readily available techniques that are decentralised as opposed to huge centralised water infrastructure. RwH, one of the cheaper and decentralised water provision techniques, is set to expand nationally to cater for South Africa's unserviced population in rural and agricultural communities which currently exceeds half the population. Larger-scale implementation of RwH will require improved management to enhance benefits and mitigate negative impacts. Increased understanding and a better synthesis of RwH techniques to be achieved in this project will lead to the development of a model-based decision-support tool as well as a policy document on the RwH

practice. The RwH decision-support tool and the policy document are set to guide and direct the RwH practice within the boundaries of integrated water resource management in accordance with the provisions of the NWA and other related legislation such as the Environmental Conservation Act. As part of the RwH decision-support tools, methodologies for quantifying socio-economic, hydrological, ecological and environmental impacts of RwH are expected to be developed and refined for packaging as standalone applications or for incorporation into existing water resource management and water systems analysis models.

Estimated cost: R2 800 000
Expected term: 2005-2008

Towards the establishment of water market institutions for effective and efficient water allocation
CPH Water
No 1569

The NWA provides for the transfer of water use licences through a water market. A recent WRC review of the value of water to different sectors of the economy has revealed that the market mechanism has proved to be an efficient tool to effect the transfer of water to more efficient users and improve water use efficiency under South African conditions. However, due to high transaction costs, this mechanism is under-utilised. In order to utilise the efficiency of market mechanisms, it would thus be necessary to institute institutions that facilitate transfer and reduce transaction costs. On the other hand, safeguards also need to be instituted to prevent potential negative externalities associated with transfers. This project will investigate three case studies to determine which steps and institutions are required to balance these requirements.

Estimated cost: R1 500 000
Expected term: 2005-2008

A philosophy and strategy enabling learning for good ecosystem governance
CSIR
No 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. In addition, the aim is also to develop a strategy and implement it using the above principles in pilot areas. As a new emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200
Expected term: 2006-2009

Institutional dimensions of water resource management in South Africa: Socio-cultural perspectives
University of Cape Town
No 1698

This project seeks to analyse, monitor and evaluate the new water management institutional arrangements by focusing on the role of socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices in determining water management outcomes. Some of the long-term benefits of the research include enhancing public participation in water management and the voices of local people, alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400
Expected term: 2006-2009

Programme 3: Pricing and financing of WRM

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development
Conningarth Economist
No 1570

Water being a limited resource, it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000
Expected term: 2005-2008

The development of a framework for the involvement of local government in water resource management linked to water service provision
Rhodes University
No 1688

Institutional arrangements supporting the implementation of the National Water Act (36 of 1998) and the Water Services Act (108 of 1997) are devolved across all three tiers of government. At a regional level, WRM is currently being transferred from regional DWAF offices to CMAs, facilitated by water user associations (WUAs) with additional stakeholder input from catchment forums including local government. Water services authorities (WSAs) are to manage water service provision (WSP); local authorities can act as WSAs. Challenges to local government are therefore considerable, particularly where capacity and financial resources are limited. Added challenges are posed by municipal and water management area boundaries that do not coincide; the inattention to the linkages required for sustainable WRM to support WSP; and little guidance given to the links between WUAs, catchment forums and local government. This project emerges from the recent call for researchers' participation in the design of Integrated WRM (IWRM) institutional arrangements research programme. Local government needs to establish WSP within an IWRM, in an environmentally sustainable manner. In order for local governments to effectively contribute to catchment WRM, understanding point and non-point source management, with questions of water quality and quantity impacts on resource management, is essential.

Estimated cost: R537 000
Expected term: 2006-2009

NEW

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

A methodology for near-real time spatial estimation of evaporation
CSIR
No 1751

Evaporation is the second largest variable of the water balance after rainfall. However, its quantification is handled at relatively lower levels of accuracy and reliability when compared to other variables such as runoff and storage. The evaporation estimation methods based on remote sensing data hold great potential. Whilst a number of developed countries have already made advances in this emerging field of research, in South Africa the application of remote sensing to interpret and to

generate near-real time evaporation estimates is a very new technique that still has to be customised and applied in local catchments. This study will investigate and review existing technology in evaporation estimation using remotely sensed data. Work with at least two international developers of satellite data interpretation software and apply customised software to selected catchments.

Estimated cost: R468 000
Expected term: 2007-2009

The identification and delineation of high-yielding well-field areas in Karoo aquifers as future water supply options to local authorities
Groundwater Africa
No 1763

There have been a number of recent initiatives to quantify and delineate high-groundwater-potential areas, but they have either been based on inadequate data, or have fallen short in providing the necessary information that can readily be used by planners. This project will address two main issues:

- Identify and quantify useable high-groundwater-potential areas in the Main Karoo Basin (through specific case studies)
- Develop the framework for incorporating the high-potential areas into the municipal, catchment and national planning models. This will allow for water resource planning at all levels to properly take into account groundwater as a bulk water source. The project will focus on the Main Karoo Basin, but the methodologies developed will be applicable to all Karoo aquifers.

Estimated cost: R3 499 200
Expected term: 2008-2011

Programme 2: Surface water / groundwater hydrology

Hydro-pedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models
UFS
No 1748

In catchment hydrology, water and soils have a very intricate relationship which is reflected in the soil water regime of specific soil horizons, the quality of released water and the catchment water balance. Hydrologists are usually restricted by a number of uncertainties in soil-related processes and other limitations where expert soils knowledge is required. This study is expected to improve data, knowledge and models in a way that provides better interaction of soils and water. In particular the study will investigate, recommend and test appropriate soil-survey procedures and the interpretation of the soil-survey data with the aim of making this information suitable for use by hydrologists at all key water management scales that are used in South Africa. The study will also provide a quantitative characterisation of the annual and seasonal soil water regimes in a range of representative local soils. The study will also seek to optimise the intensity of soil-survey information that contributes effectively to hydrological modelling.

Estimated cost: R1 873 500
Expected term: 2007-2011

Influence of catchment development on peak urban runoff
UP
No 1752

Developments in urban and informal areas are regulated with regard to the potential flooding by the NWA. The 1:100 year flood line is used to define the extent of the development. Furthermore it is required by the municipal authorities that all developers should create temporal storage if the development contributes to an increase in flood peaks. This study will provide a quantification of the influence of a catchment development on the flow rate and volume of runoff. The study will contribute to an effective stormwater drainage design and optimisation of costs for the upgrade of hydraulic infrastructures in targeted urban areas.

Estimated cost: R665 000
Expected term: 2007-2010

Land-water linkages: Agent-based modelling of land-use change and its impact on water resources in the Modder River Basin
Central University of Technology, Free State
No 1753

Changes in land-use have profound impacts on water resources. This study applies agent-based modelling to investigate land-use changes and how these have impacted on water resources in the Modder River Basin. While previous studies of land-use changes have addressed simplistic representations of two or three driving forces, the agent-based modelling technique will involve several situation-specific interactions among a large number of factors at different spatial and temporal scales. The main objective of this research project is to analyse land-use changes and highlight the dynamic nature of coupled human-environment systems using agent-based modelling in relation to land-use change and its impact on water resources.

Estimated cost: R357 000
Expected term: 2007-2010

Measurement of the bulk flow and transport characteristics of selected fractured rock aquifer systems in South Africa
UFS
No 1760

In South Africa, more than 90% of the aquifers are of a fractured nature. The physical properties of geological materials exert a significant influence on the storage and ability of fluids to move through them. The existing theory of flow cannot fully account for flow through fractured rocks. Field-scale studies and direct observations/measurements are the most robust means of developing and calibrating models of flow and transport in fractured-rock aquifers. As a result these fractured-aquifer systems can be better exploited and managed through:

- Developing appropriate innovative methodologies/approaches to measure bulk flow and transport characteristics of fractured-rock aquifers and of up-scaling those to appropriate scales and resolution
- Developing guidelines for future well-field developments in fractured aquifers

Estimated cost: R3 353 940
Expected term: 2007-2011

Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater
UFS
No 1766

The programme outputs will establish an improved understanding of the origin of pollutants, the pathways of these pollutants into the environment and the ultimate fate of these pollutants (LNAPLs). This project will produce tested techniques and guidelines for application in the industry. Available approaches are usually based on international case studies dealing mostly with porous aquifers. South African specific case studies will enable a better understanding of the behaviour of LNAPLs in the subsurface with a specific emphasis on the fractured-rock environments.

Estimated cost: R3 500 357
Expected term: 2007-2011

Programme 3: Water resource planning

National water resource planning for operational needs: an update of applied approaches (Phase 1)
Clear Pure Water cc
No 1750

Continuous national water resource assessments and planning are imperative given the changes in several determining variables. Some of these key variables are the national goals, climatic regimes, water-demand patterns as a result of demographic

shifts and economic developments as well as improved data and knowledge in water resource processes. This research is expected to investigate the currently applied local and international water resource assessment and planning concepts, methods and tools; to identify areas for development and improvement in current water resource planning and assessment practices; to develop, revise and strengthen current approaches; to apply these approaches to selected catchments; and to motivate the revised approaches for national use. The project will also aim to generate the most up-to-date water resource assessment and planning practices of a generally uniform reliability that generate similar confidence levels across the country at significantly higher spatial and temporal resolution than presently targeted. The project will start with a consultancy project to deal with investigation of local and international practices as well as the conceptualisation of the operational planning approach that will be developed.

Estimated cost: R2 300 000
Expected term: 2007-2011

Programme 4: Water resource development

The development and calibration of South Africa's National Standards for water retaining structures
US
No 1764

The design of water-retaining structures in South Africa is often based on the British Standards for the reason that a local national code of standards does not exist. The British Standards which are currently in use in South Africa will soon be superseded by the Euro-codes, thus leaving the local practitioners with the dilemma of having to adopt yet another new foreign standard with no reference to South Africa or to develop new regionalised standards for the country. This research project will firstly exploit the extensive international and national research aimed at deriving rational design rules for civil engineering infrastructure and buildings. The research will ultimately lead to the development of the South African National Standards for water-retaining structures including the rainwater harvesting storage facilities.

Estimated cost: R1 100 000
Expected term: 2007-2010

Review and update of the SANCOLD Guidelines for the design of freeboard of dams
US
No 1759

A DWAF survey has estimated that as many as 37% of dams in South Africa have inadequately sized spillways with a high likelihood of spillway failure. The lack of sufficient freeboard at dams also contributes to dam failures. The existing interim freeboard design guidelines *Freeboard for Dams* was published as a draft guideline in 1988 by SANCOLD. This document is still being used in the design of new dams, but a number of aspects of the document have become outdated. This project will review and update the existing guidelines for the design of dam freeboards. The project will improve the design provisions for wind, wave and surge effects on dam freeboards.

Estimated cost: R320 000
Expected term: 2008-2009

Programme 5: Climate change and hydro-climatic variability

Multidisciplinary analysis of hydro-climatic variability at the catchment scale
University of Cape Town
No 1747

Climate research has made major advances in improving the understanding of large-scale climate variability, with emphasis on global and in some cases regional scales. Local climate research has hardly touched on the conceptual understanding of ocean-atmosphere linkages to hydro-climatic variability at catchment scales. These are the scales that are more relevant to local water resource management and planning. The research will improve and refine our knowledge of how the large-scale climatic variations impact on smaller and localised hydrological scales. The research will lead to a better understanding of the mechanisms responsible for droughts, wet spells, floods and the variability of rainfall in Southern Africa at the catchment scale.

Estimated cost: R1 743 955
Expected term: 2007-2010

Programme 6: Water resource quality management

Water quality monitoring data and target users: Maximising value
CSIR
No 1755

DWAF operates a vast water quality monitoring network. The information transfer which should form an integral part of the design of such networks is not functioning optimally at present. Much of the value of water quality information is lost if it is not effectively conveyed to users. This project will aim to maximise the value of water quality monitoring programmes by optimising the way in which information is transferred to users. This could have a knock-on effect regarding the appreciation of water quality management by politicians and the man in the street.

Estimated cost: R488 960
Expected term: 2007-2008

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 2: Human-induced effects

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water
CSIR
No 1749

DWAF is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles were used in the *1996 South African Water Quality Guidelines* (Vol 6: *Aquatic Environment*) the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in characterising the biotic effect of various endocrinal active substances at various levels of biological organisation, critical interpretational gaps remain. In its commonly used paradigm, health-risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water. The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500
Expected term: 2007-2009

A national survey of mercury levels in South African resources
CSIR
No 1754

Recent estimates indicate that Hg emissions from sources in South Africa, mostly coal combustion and gold mining, contribute more than 10% to the global Hg emissions, thereby ranking the country second after China, on the list of major Hg polluters globally. Mercury (Hg) pollution is a world-wide problem that should be addressed at global, regional and national levels. Mercury is released into the atmosphere from anthropogenic sources both as elemental Hg (Hg0) and in the ionic oxidised form (HgII). The major

concern with Hg0 is that once released into the atmosphere, it is oxidised contributing to the oxidised Hg pool. This HgII is very water-soluble, and is removed from the atmosphere by both wet and dry deposition and enters freshwater and marine resources, where it is rapidly converted into the more toxic methyl-mercury (CH3Hg) form. This more toxic form bio-accumulates in the aquatic food chain and poses a serious health risk to humans who consume fish or other aquatic organisms that are contaminated with CH3Hg. Anthropogenic activities such as artisan gold-mining activities, industrial and small-scale coal combustion, as sources of Hg in the atmosphere, the deposit thereof into water resources, and its effects on water quality, are not well characterised in South Africa. Accordingly, as one important step towards such characterisation, this project aims to carry out a national survey of Hg levels in South African water resources. This should provide a sound basis for establishing the extent to which Hg is currently a problem in South Africa. The aims of the study are to survey the levels and speciation of mercury in water, sediments and biota in priority South African water resource; to assess the degree of compliance of the measured mercury levels with national and international guidelines; to assess the degree to which mercury may be a problematic pollutant in South Africa; and to create local capacity relating to mercury sampling and analysis.

Estimated cost: R918 850
Expected term: 2007-2009

Investigation into the effects of water quality (organic vs. inorganic) on the immune systems of humans
University of the Western Cape
No 1756

This will be a comprehensive study of the effects of water quality on the immune system of humans. The quality of potable and raw water could vary considerably from place to place and this depends on the microbiological and chemical constituents of the water. Several of the physiological systems (e.g. immune, thyroid-hypothalamus, reproductive and the neuro-physiological system) can be impacted on by the quality of the water. The complexity of mixtures is that different constituents (depending on the concentration of each) could have synergistic or antagonistic or no effects in the particular mixture on the human body. Some man-made chemicals affect the function of one or more immune pathways and this can have adverse effects on the health of man and animals. The objective of the study will be to develop and validate analytical tools to evaluate the impact of aquatic pollutants on the immune system. Water extracts obtained from various areas will be evaluated for its immunotoxicity and analytical procedures will be verified to measure the different effects on the human immune system.

Estimated cost: R1 500 000
Expected term: 2007-2010

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

Review and detailed design of terms of reference for RDM Version 2 manuals
To be solicited
No 1703

A project was commissioned by the WRC to compile a list of current initiatives related to RDM tools and methodologies that are used in South Africa to enable the WRC and its stakeholders to identify technical and implementation gaps that can be addressed through research. The report with a list of projects conducted and completed between 1999 and 2004 is available and there is now a need to critically evaluate the projects' outcome and implementation potential of the products from those projects. The analysis of the previous projects will lead to the formulation of new research topics that address identified research or technical gaps important in developing and implementation of RDM.

Estimated cost: R2 000 000
Expected term: 2007-2010

Investigation of the positive and negative consequences associated with the introduction of low-P detergents
University of KwaZulu-Natal (Pietermaritzburg)
No 1768

Eutrophication is rated as one of the major water quality problems being experienced by South Africa. Eutrophication, in specific the accumulation of phosphorus (P), gives rise to serious problems with the water quality management of South African dams. It is estimated that up to 50% of P in South African sewage comes from detergents. This project will investigate the positive and negative consequences that the introduction of detergents with lower P contents would have on the eutrophication of dams, users of detergents, water and waste-water treatment works and the waste discharge charges system.

Estimated cost: R689 200
Expected term: 2007-2009

Development of a conceptual framework for the regulation of water quality within the context of an integrated, preventative management approach
Golder Associates Africa (Pty) Ltd
No 1769

The implementation of the integrated preventive management approach that guides the *DWAF Drinking Water Quality Management Framework for South Africa* (2005) and *WHO Water Quality Guidelines* (2004) requires a well coordinated regulatory system for the management of the entire water supply system from the catchment to the consumer and the quality of effluents discharged into the water resources. Currently, the linkages between water resource management and drinking water quality management are not strongly followed nor addressed within the regulatory framework. Therefore, this project aims to develop a conceptual framework for integrating the regulation of the quality of water resources with that of drinking water quality in order to support the implementation of the integrated, preventive management approach.

Estimated cost: R600 000
Expected term: 2007-2009

Implementation of ecological hazard assessment of industrial waste discharge at local municipal level, comparing toxicity test methods
Rhodes University
No 1757

This project is aimed at conducting a complete cost analyses of the use of toxicity test kits vs. indigenous species and the recommended DEEEP methodologies for analyses of complex industrial and sewage discharges, including in-house vs. outsourcing of tests. Assess the applicability of hazard assessment based on a literature review of eco-toxicological endpoints obtained from the use of toxicity kits vs. standard laboratory organisms vs. South African indigenous organisms. Test the sensitivities of the different test methods (kits vs. the use of standard laboratory organisms vs. the use of indigenous organisms) using 4 complex effluents representing a waste water treatment works and a range of industries. Assess the ecological relevance, usefulness and ease of implementation of the kits vs. standard laboratory organisms vs. indigenous organisms for implementation of the DEEEP at local municipal level. Capacity building and awareness of technical staff of the municipality and industries from whom the samples were taken, with regards to the DEEEP, toxicity test results, and implications of the resulting endpoints.

Estimated cost: R200 000
Expected term: 2007-2008

Programme 3: Integrated river flow and catchment hydraulics

Sedimentation and sediment yield maps for South Africa
US
No 1765

Loss of storage capacity in dams due to sedimentation is a major strategic threat to our country's available water resources. Soil erosion and therefore sediment yield and reservoir sedimentation is accelerated by human activities such as clearing of vegetation and poor farming practices. In order to regulate and manage these negative actions, it is important to have accurate national maps of eroded areas and sediment yield. The sediment yield maps to be developed in this project are expected to assist DWAF in mitigating sedimentation impacts and making adequate provisions for sedimentation in dam developments. The better understanding of localised sedimentation processes from this research will feed into the land and soils conservation and management practices which are major concerns in farming communities and the national Department of Agriculture.

Estimated cost: R1 400 000
Expected term: 2007-2010

South African Handbook on Environmental Hydraulics
Ninham Shand
No 1767

A great deal of river hydraulics knowledge has been gained through WRC projects. In the past research projects have addressed a number of subjects which have included flow hydraulics, sediment transport and deposition which are cornerstones of environmental studies. The knowledge gained from WRC research has been accumulated into a number of research reports, some of which are no longer available for distribution. This project will seek to collate available knowledge and experiences and integrate these into a user-friendly handbook of river hydraulics. The project will engage several experts to contribute on their specific research areas.

Estimated cost: R920 000
Expected term: 2007-2009

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Development of the AWARE model for the Inkomati CMS
Targeted Solicited
No 1573

This project was listed in the *2006/07 Business Plan*. The project title was: **Processes and relationships between CMAs and other organs of society**. The topic has been covered by a number of other projects on cooperative governance and has been replaced with a more relevant area. The team that developed the AWARE model will be targeted to continue with populating and customising it for the Inkomati basin. The budget remains the same. The new water management institutions have the complex task of matching different and sometimes contradictory objectives in a socio-economic context characterised by inequalities, lack of or asymmetry of information, and conflicting interests. Hence, a clear need for negotiation and decision-support tools for these institutions is perceived. CMAs and WUAs will have to put in place processes of participatory decision making and facilitate negotiation among water users having different socio-economic characteristics, unequal access to information and knowledge, and therefore a different capacity with regard to lobbying and negotiation. The AWARE model is a tool developed for the Kat River as simulation model involving role-playing games, able to represent the complexity and the uncertainty of the above-mentioned processes which has a great potential to support the CMA board to make informed decisions.

Estimated cost: R1 800 000
Expected term: 2007-2010

The criteria necessary for the success of women in the water sector
Palmer Development Group
No 1762

A number of successful women can be found in the political, corporate and the business worlds in South Africa. Whether their success can be attributed to positive family endowments such as well-defined gender roles at the home and/or community level, the enabling legislation in support of gender parity, etc., or a combination of all the above, might explain why still only few women manage to make it to the top echelons. The project will seek to personalise the success by investigating real-life examples to draw out the criteria necessary for the success of women in the water sector. The intention is to uplift those feeling disempowered and to identify gaps if any hindering the progress of women in the water arena.

Estimated cost: R712 320
Expected term: 2007-2010

Programme 4: Transboundary water resources

Review of the involvements of national water institutions and civil society in international agreements in South Africa
Pegasys Strategic Management
No 1758

Water management institutional reform is taking place within most of the Southern Africa Development Community (SADC) countries, and new local catchment councils and/or agencies are already in existence in the respective countries. At higher interstate levels, Shared River Commissions are established in accordance with the SADC protocol on shared rivers. To date little or no attention has been paid to the interaction and integration of local actors vs. international bodies and the quest to separate the governance and implementation/management dimensions in internationally shared rivers for effective management and long-term sustainable use of such resources. This project could look at some examples such as the Inko-Maputo Agreement and the roles and responsibilities of the different local and international role-players to ensure effective implementation. Other examples can also be considered.

Estimated cost: R3 000 000
Expected term: 2007-2010

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KSA 2: Water-Linked Ecosystems

Dr Steve Mitchell | Director |
Water Research Commission

Healthy people depend on a healthy environment. This is particularly true in the case of the rural poor who rely directly on the environment for their livelihood. For instance, while poor quality water can be improved in treatment works (at increased cost), those directly dependant on the resource will suffer the consequences of drinking water containing pollutants or disease-causing organisms. At the same time, the flow of goods and services such as fish, fibres as well as cultivated and medicinal plants from a poor quality ecosystem will be less than it should be. For these and other reasons, sustainable management of the ecosystems making up the environment is central to an improved quality of life. The scale of ecosystem benefits vary from individual, for example fibre for mat and basket weaving or medicinal benefits for individual livelihoods, to universal, such as good quality water for abstraction and urban use and intact wetlands to aid in the improvement of water quality and flood attenuation. In short, society cannot survive without the underpinning support from the environment.

Research undertaken within this KSA will continue to address the conservation of aquatic ecosystems in order to provide the knowledge for their sustainable functioning in terms of the national commitment to international conventions and the ongoing provision of goods and services which ecosystems deliver. In addition, the National Water Resource Strategy (NWRS) focuses on resource protection as one of its components. The research undertaken in this KSA provides knowledge for protection of the resource, and is therefore central to this aspect of the NWRS. No major changes in strategic direction are envisaged and the research portfolio as presented in the previous year's strategy was found to be sound and applicable. Deviations in programme focus or structure are highlighted in the following text.

SCOPE

Water-linked ecosystems are defined as in-stream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river) and water table-dependent (dependent on a water table, but not on surface water). This KSA focuses on the protection and sustainable utilisation of the aquatic environment and biota (in-stream, riparian and groundwater). This includes the research needs around the international conventions on environmental management (e.g. biodiversity) as well as human needs from the aquatic environment (e.g. sustainable management for equitable ecosystem resource utilisation, recreation and ecotourism).

The above will be achieved by developing technologies and methodologies, adaptive management processes and capacity to protect the resource and to sustain the flow of goods and services in a time of both demographic and climatic change in the Southern African context. Technologies and methodologies will be developed within this KSA to support the implementation of the national water policy to ensure sustainable resource use.

OBJECTIVES

In the light of international trends in research, the portfolio of research falling within the scope of and addressing this KSA has been adjusted. However, the main (primary) and secondary objectives of this KSA have been reviewed and found to appropriately address future research need scenarios. The main objective is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water; and to develop an understanding of the ecological processes underlying the delivery of goods and linked ecosystems in a water-scarce country during a time of demographic and climate change.

This will be achieved through the following (secondary) objectives aiming to:

- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems
- Transfer the knowledge to the appropriate end-users, with special emphasis on decision makers and the community
- Build capacity in both research and management to sustainably manage aquatic ecosystems.

THRUSTS AND PROGRAMMES

As indicated above, the research portfolio presented here does not deviate materially from that presented in the previous year's plan. However, a new programme on impoundments was introduced last year under the thrust addressing Ecosystem Processes and is progressing well. A general description of thrust and programme structure is presented below. New initiatives and current projects have been grouped into strategic thrusts and programmes which directly address the above-mentioned objectives and are summarised as follows:

THRUST 1: ECOSYSTEM PROCESSES

Scope: This thrust includes research addressing the biophysical processes, form and function of ecosystems. This understanding will assist those managing the resource (water services, crop and aquaculture, biodiversity, etc.) to maximise socio-economic benefits in a sustainable manner. The aim is to generate knowledge to inform policy and management. Current programmes are:

- Estuarine processes
- Riverine processes
- Wetland processes
- Groundwater-dependent ecosystems
- Impoundments.

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings. The following programmes are addressed:

- Ecological Reserve
- Estuary management
- Ecosystem health
- Environmental water quality
- Endocrine disrupting compounds in water sources
- Socio-economic considerations
- Ecosystem governance.

THRUST 3: ECOSYSTEM REHABILITATION

Scope: This thrust addresses the rehabilitation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities with the view to restoring, as far as possible, process, form and function in order to provide the stream of goods and services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Capacity will be built to implement the research findings. Programmes include:

- Wetland rehabilitation
- River rehabilitation
- Influence of instream-constructed barriers.

RESEARCH PORTFOLIO FOR 2007/08

This KSA focuses on the protection and sustainable utilisation of the aquatic environment (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. It addresses national research needs (strategic and shorter term) as well as those of international conventions on environmental management (e.g. wetland conservation [RAMSAR] and biodiversity). Work done within this KSA has contributed to the development of the National Water Act (NWA) of 1998 and associated policies, an example being the Ecological Reserve. This has meant that work within this field has not only addressed the strategic needs of the country which have increased in line with the increased global recognition of the importance of the role of sustainable environmental management, but also has addressed some of the immediate research needs related to the NWA and its implementation. What people require of the environment is an area of increasing importance, and the building of capacity amongst the country's citizens (managers and the various user groups) to manage the environment sustainably is of cardinal importance. The proposed new projects will continue to develop knowledge to enhance the national capacity to ensure sustainable management and utilisation of ecosystems, while maintaining diversity in the form and function of ecosystems.

Research will be solicited in the following areas during 2007/08 and will commence in 2008:

ECOLOGICAL RESERVE DETERMINATION FOR WETLANDS

Wetlands are complex systems which alternate between complete inundation and being dry enough to support terrestrial activities. In climates where the rainfall is highly variable, the degree of inundation during the wet cycles will not always be the same, yet these ecosystems are important and productive components of the environment. This non-perenniality makes them more akin to non-perennial than perennial rivers, but the ecosystems and the range of benefits delivered by them are more complex. These important systems need to be kept in good condition to enable them to maintain their functions.

WATER IN THE TERRESTRIAL ENVIRONMENT

The aquatic and terrestrial environments tend to be separated at all levels (e.g. research, management), and yet water provides crucial services in the terrestrial environment as well as making critical linkages between the two. Current management practices in protected areas keep the two 'environments' separate, while the reality is that they are components of the landscape and cannot be separated if proper sustainable management is to be successful. This is equally true for modified environments such as the agricultural and urban environments. Research done in this project will quantify the linkages involved in this relationship in the natural environment to provide a fuller understanding of the processes integrating the different components of the landscape.

National Wetland Research Programme Phase 3 – Wise Use of Wetlands: The initial Terms of Reference (Tor) as envisaged in 2002 will be updated during the early part of 2006 in time for the call for proposals. The study is becoming increasingly necessary as NDA are starting the process of drawing up a new policy for agriculture in wetlands. There is also increasing interest in this topic internationally, with Wetlands International holding a workshop at St Lucia, KwaZulu-Natal at the end of January 2006 and a resolution on this was discussed at the recent RAMSAR COP.

Kruger National Park Rivers Research Programme Phase 4: ToRs have been developed during the course of 2006-07 for this initiative and the project was implemented through the course of 2007-08.

Non-solicited research: Projects researching ecosystem processes will be given preference during the 2007/08 cycle.

BUDGET FOR 2007/08

The approved funding of the research portfolio for 2007/08 leads to a committed funding budget of R11 066 241. The focus of this portfolio will continue along the current trends.

CORE STRATEGY

The core strategy is fundamentally unchanged from 2006/07 apart from the shift in emphasis recommended by the Institutional Review of July 2006. Research funded from within this KSA will continue to address, within the mission and vision of the WRC, issues of sustainable use and the needs of the legislation and international conventions of South Africa. The Review panel made a number of recommendations, and these are implemented in the appropriate paragraphs below.

STRATEGIC CONTEXT

The KSA for **Water-Linked Ecosystems** may be defined both by the physical boundaries of the area addressed by the KSA, as well as by the strategic role occupied by the WRC in the field, with relevance to organisations active in ecosystem research and management. Physically, the field includes aquatic and riparian ecosystems as well as those dependent on groundwater.

Research funded through this KSA provides knowledge for the protection of the resource and the biodiversity of aquatic ecosystems, thus addressing the commitment of international conventions as well as the needs of policy as well as sustaining the capability of the environment to support the flow of benefits on which society depends.

The position of the WRC in funding research into ecosystems

Aquatic ecosystems comprise the resource in terms of the NWA. Even without this they are important for a number of reasons. They provide a barometer of ecosystem health, and hence environmental quality, which is responsive to change and easy to interpret. They also provide a number of goods and services which are used by all sectors of the population. Examples of these are water for domestic, agricultural and industrial use, polishing of effluents, basic food and fibre (fish, plants), traditional medicines and recreation opportunities to name a few. A stable ecosystem provides the necessary resilience to cope with extreme events such as floods and droughts (natural) and pollution events (anthropogenic). In the past a proportion of the national cost for the treatment of wastes was externalised to the

environment and although the environment was degraded by this, by and large the load did not exceed the capacity of the environment to cope with it. However, it is beneficial for all to maintain the resource in a good condition than to carry the costs associated with a poor quality resource.

To this end, the WRC has funded research on ecosystems since the latter part of the 1980s. The work funded has been a balance between the generation of knowledge needed to support resource management and the generation of understanding of the ecosystem processes to guide future resource management direction. Some examples of this from research funded during 2006/07 are the funding of research on the sustainable management of estuaries aimed at empowering local authorities to better manage their natural resources, research on the development of cross-sectoral policy on biodiversity conservation aimed at providing all tiers of government with the knowledge to protect South Africa's unique biodiversity without stifling development and research on conservation planning.

The WRC, with its mandate to improve the national capability to sustainably manage water in the country, has a specific role which differs from that of other research funders. The WRC needs to support DWAF and other government departments in their objectives to effectively manage the national water resource. Although in some cases there is an overlap, there is opportunity for synergy with other sources of funds, as the breadth of work funded by the WRC covers the short-term to longer-term strategic needs of the country, and ranges from more fundamental to highly applied work within the area defined by the mandate.

NEEDS ANALYSIS

Identified in previous years is the urgent need for the generation of the ability to implement the new legislation such as the NWA. In this regard this KSA closely supports DWAF, DEAT and other government departments and initiatives. However, the need also exists, possibly more than ever, for strategic research for innovation, the lead for which may come from global trends not necessarily yet reflected as needs in South Africa. The need to implement legislation tends to distract attention from this long-term need, although this is handled proactively as far as possible within this KSA so that anticipated research products are available when needed. The External Review also identified the support of research to address the longer-term needs of the country as requiring special attention. The capability to sustainably manage ecosystems is an overarching need which this KSA addresses. In addition, involving both the decision makers and the community in the above is key to the successful implementation of the research findings.

At the higher level, it is necessary to improve the interface between scientists on the one hand and managers and the public, including rural communities, on the other. Without this, the concept of sustainable management will remain in the realm of theory. The External Review identified that the implementation of research findings required specific attention and this will be addressed within the KSA through a WRC-wide initiative which will be implemented during the year.

Research is needed to address the processes and functions of various components of aquatic ecosystems. It is becoming increasingly apparent that with the switch to largely addressing the needs of management over the last decade and a half, we are reaching the limits of current knowledge. More research needs to be initiated in selected areas in order to ensure that our knowledge remains ahead of the need to apply it.

At the operational level, in addition to the issues around the implementation of legislation, there is a need to provide knowledge on the mitigation of the effect of development on ecosystems.

OVERVIEW OF TECHNOLOGICAL TRENDS RELATED TO NEEDS

Several important recent trends in inland water research have been emerging internationally, and these are briefly discussed below. Some of these trends were already mentioned in the business plan of the previous year, but with new knowledge available, more information regarding some of these trends is given in the following text. These trends are being implemented in the medium- to long-term planning within the KSA where they are relevant to the country.

- **Climate change.** New knowledge further emphasises the importance of the phenomenon of climate change. There is an increasing body of knowledge on the effects of climate change from the temperate latitudes, but this deals largely with increasing temperature. More relevant to Southern Africa is the predicted change in rainfall, with the dry west becoming drier. The ramifications of this for management of the resource could be substantial.
- **Impoundment management.** Toxic blue-green algal blooms resulting from the eutrophication of impoundments continue to pose a problem worldwide. Locally, as indicated previously, research work internationally is addressing the possibility of managing the natural ecological processes within these impoundments in order to reduce the impact of these blooms. The ability to do this would not only protect the natural environment, but would also assist in keeping the cost of water treatment down.
- **Natural resources as a source for livelihoods.** Linking ecosystem utilisation to poverty alleviation and food security means the effective and sustainable management of ecosystems.
- **Conflicts** between water for food and water for the environment is a key research initiative globally (led by the world bank CGIAR, Challenge Programme).
- **Natural resource accounting** is becoming widely accepted as a way to bring environmental values into the macro-economy of countries. Research is being initiated to generate methods for linking the allocation of water resources to the value of ecosystem benefits.
- In Europe there is a continued surge of interest in the development of **environmental water quality indices** based on diatoms. These appear to be more successful than previous attempts at correlation as it appears that new methods of data analysis are being used. Research funded by the WRC has shown that South Africa can use this in the management of water quality, and research is being commissioned which will embed the methods into existing monitoring networks such as the River Health Programme as well as the programmes of water utilities.
- The successful implementation of all of the above hinges on thorough knowledge of **ecosystem functions and processes** as well as the will to implement.

Portfolio planning. As indicated in the previous years' business plans, national research drivers in ecosystem research continue to be aligned with international trends, although the emphasis is on the local situation. The current research drivers do not deviate greatly from previous year and include:

- Ecosystem processes and functions. Research into these aspects is important for the sustainable management of ecosystems and it is anticipated that this will remain a priority research driver for the foreseeable future. Research in this area provides the basic understanding on which management decisions may be based.
- The Ecological Reserve provides a tool which enables managers to balance resource use with sustainability. Version II of the Resource Directed Measures (RDM) Manual is being developed, and it is anticipated that the process to determine the Reserve will become a lot more stable once this is out. As this happens, the need for new research in this field should decline sharply. Projections for this research topic are that within 5 to 6, years it will require considerably less funding than it has at the moment, and in about 10 years it will be phased out. A possible exception to this may be wetlands, as methods for determining the Reserve in these complex systems have not yet been finalised.

- Cooperative environmental management and governance is being developed within the context of research programmes addressing estuaries, wetlands, the Ecological Reserve and other initiatives. This develops the capability to integrate ecosystem management with the social and economic requirements of the stakeholders.

Within the current estuaries research programme much progress has been made in locating the management of

Key stakeholders (influencers)

The key stakeholders remain largely unchanged. In addition to the Minister of Water Affairs and Forestry and DWAF, other government departments such as DEAT are of importance. This KSA closely supports DWAF specifically at this time when they are implementing new legislation. Provincial and local government form another group of stakeholders, and the anticipated needs of catchment management agencies (CMAs) influence research direction. Other end-users of the research are rural communities and others living on the land.

Donor funding is available in this field, usually for specific tasks which satisfy the donors' mandate. The largest funder is the Global Environment Facility (GEF), funded by the World Bank, which has been instrumental in establishing large biosphere reserves as well as the Cape Action Plan for the Environment (CAPE) in South Africa. Both the IUCN and Wetlands International, (international non-government organisations (NGOs) fund specific projects within their mandates in this field, and the latter is becoming increasingly active in Africa. Funding may also be available from industry for specific projects.

STRATEGIC INITIATIVES

National initiatives

Participation in national committees related to this KSA:

- Steering Committees (National)
  - The River Health Programme. The WRC is 1 of 3 national custodians of this programme
  - Executive Committee of DWAF's 'Adopt-a-River' programme
  - South African Environmental Observation Network (SAEON) – technical committee
  - Benefit/cost analysis of DWAF's monitoring programmes – steering committee
  - Wetland Inventory advisory committee - Working for Wetlands
  - Member of the South African Mercury Association (SAMA)
  - Working for Wetlands steering committee
  - Co-chair of FETWater (with DWAF)
- Leadership positions: (within South Africa)
  - Board of the National Community Water and Sanitation Institute, University of the North (Chairperson, SA Mitchell) – now less active
  - Member of the ARC Board
  - Institute of Water Research, Rhodes University
  - National Science and Technology Foundation – Executive Committee representing the Science Council Sector Chair NSTF Science Councils Sector meeting – 23 November 2006
  - Consortium for Estuarine Research and Management (CERM) – Coordinate for the WRC – WRC the lead organisation
  - Overall leader of the FETWater project (implementing agent for DWAF)
- Yellowfish Working Group
- Working for Wetlands / Mondi Wetlands Project Wise Use workshop (28 June)
- SAASTA career guidance – presentation at University of Pretoria and live radio interview on my career and life (4 September)
- Launch of the Wetlands Rehabilitation publications at the Wetlands Indaba (23 October)
- Harties-Metsi-a-Me project – WRC to give leadership on the research and development (R&D) needs
- National Freshwater Biodiversity Collaboration (3 April).

International player

- IWMI's 'SADC Sustainable Use of Wetlands' project – steering committee chair (4-5 July)
- FETWater signing ceremony – UNESCO, DWAF and WRC (19 July)
- Recipient of the **2007 Marquis Who's Who in Science and Engineering Award**, which distinguishes the most accomplished people in their science and engineering fields in the USA
- MS Liphadzi co-authored a book chapter: F Madrid, **MS Liphadzi** and MB Kirkham (2008) 'EDTA-assisted phytostabilisation by barley roots contaminated with heavy metals' and published it in: R. Naidu (ed.) *Chemical Bioavailability in the Terrestrial Environment, Development in Soil Science*. Vol. **32**. Academic Press, Elsevier Science, USA. pp 695-716.
- FETWater technical visit to Europe (26 November to 5 December)
- IWRM – UNESCO IHP Conference (Cape Town) – rapporteur on 2nd day's proceedings
- Reviewer of scientific papers for 5 Elsevier journals: *J. Hazardous Waste; Chemosphere J.; Environ. Pollut. J.; Arch. Environ. Contam. Toxicol; Sci. Total Environ. J.*
- Presented a paper on 'Investigating the role of capacity building in the implementation of the Ecological Reserve in South Africa' in the International River Symposium and Environmental Flows Conference, 2-7 September 2007, Brisbane, Australia
- Organised and chaired a UNEP Workshop on Vulnerability of Water Resources in Africa
- Organised and chaired 3 NEPAD workshops on the Establishment of Centres of Excellence in water science and technology in Africa
- Initiation and organisation of the international conference entitled 'Implementing Environmental Water Allocations.'

GROWING THE KNOWLEDGE BASE

The table on page 50 illustrates the number of post-graduate students who benefited from WRC-funded research in this KSA in 2007/08. This is in line with the set targets.

Organisation	Students from PD background	Total number of students
Anchor Consulting	13	15
AWARD	1	1
CSIR	2	7
DH Environmental Consulting	2	3
Institute of Natural Resources	0	0
Nelson Mandela Metropolitan University	3	12
North West University	2	4
Pulles, Howard and de Lange	4	9
Rhodes University	4	8
South African Institute of Aquatic Biodiversity	2	7
University of Cape Town	6	20
University of the Free State	2	5
University of KwaZulu-Natal	20	40
University of Limpopo	3	4
University of Pretoria		3
University of the Western Cape	2	5
University of the Witwatersrand	5	15
	71	**158**

Out of 158 students, 71 (45%) were from previously disadvantaged backgrounds. At 158, this is the highest number of students supported by KSA 2 thus far.

In addition to the postgraduate students above, 2 projects which were specifically designed to give training in areas of need were successfully completed. The project 'Profiling estuaries in integrated development planning' (**WRC Project No K5/1485**) developed courseware to train municipal officials on the inclusion of estuaries in their IDP. These courses were presented to 100 officials in 3 local authorities (Ethikweni, Port St John's and Buffalo City). Methods that have been developed for EDC analysis have been taken to other laboratories, so increasing the number of laboratories with this capability in South Africa.

The KSA participated in a number of initiatives contributing to the water-centred knowledge base in South Africa. These initiatives included participation at open days and arrangement of technology transfer workshops (including participation).
KSA staff contributed to and attended the internal WRC Open Day and the DWAF Open Day.

Scientific technical workshops

The KSA led, participated in and/or supported 12 technical workshops as follows:

- 2 workshops – Environmental flows in non-perennial rivers (12-13 March and 17-18 October)
- 'Mental Models' workshop (14-25 April, SA Mitchell) – co-funded by SANParks
- SAIAB/CERM workshop on Open-Closed estuaries 18 April 2007
- Integrating customary/local management regimes for freshwater resources management (WRM) into statutory institutional arrangements May 2007 AWARD
- Development of guidance manuals for the management of EDCs 4-6 June 2007 US/ WRC
- Initiate the development of network work plans and the FETWater business plan. WRC 23 July 2007 (SAM)
- Wetland rehabilitation – University of KwaZulu-Natal (20 July)
- Shared Rivers Initiative strategic planning workshop (Milly's) 1 Oct 2007
- Freshwater Biodiversity Scorecard development (with SANBI 30-31 October)
- Water use by indigenous trees – participant in KSA 4 workshop
- Governance of freshwater conservation – UCT (29 January 2008).

Staff of the KSA attended the following conferences:

- Water in Protected Areas (presentation entitled 'Protection of water in South African National Parks taking the Kruger National Park as a case study' (25-27 April)
- WISA conference in Durban, KwaZulu-Natal
- International River Symposium & Environmental Flows Conference, Brisbane, Australia 1-9 September 2007
- IWRM – IHP 2008 conference (9-12 March 2008)

Knowledge Dissemination

The booklet 'Watermark' has been widely acclaimed and is being widely used. It is about to be revised and the 2nd edition will be published in early 2008/09.

Innovation

The twin channel vertical slot fish-way designed during WRC-funded research (**WRC Project No 1409**) has revolutionised fish-way design, and is currently being incorporated into 2 DWAF crump weirs being built on the Orange River.

IMPLEMENTATION PLAN

Research portfolio for 2007/08

In essence, the implementation plan follows that of previous years in that the primary objective of this research portfolio is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

This will continue to be achieved through the following:

1. Develop an understanding of the ecological processes underlying the delivery of goods and services.
2. Develop the knowledge to sustainably manage, protect, utilise and rehabilitate the aquatic ecosystem.
3. Transfer the knowledge to appropriate end-users.
4. Build capacity in both research and management to sustainably manage aquatic ecosystems.
5. Increased emphasis will be placed on points 3 and 4 above.

The research portfolio (broken down into thrusts and programmes) is presented in **Table 1**. A 6th programme (on Socio-Economic Considerations) and a 7th programme (on Ecosystem Governance) has been added to Thrust 2, as there is a need for research on these.

EXPECTED OUTCOMES

Each programme within each thrust is designed to deliver products which are needed by specific end-users in the short, medium and longterm. In the case of the thrusts on ecosystem management and utilisation as well as ecosystem rehabilitation, the end-users will largely be managers and policy makers, while in the case of ecosystem processes the end users may be the same as above. The research will also provide the basis on which the more applied research would be based. The exception to this is research on the secondary effects of climate change on aquatic ecosystems which is more 'fundamental', but of long-term importance. At the moment we do not understand what effects climate change may have on ecosystems.

Each programme is designed with the input of the relevant stakeholders, taking global trends into account, and so is able specifically to address the needs expressed, and benefit the country.

Products are planned, as far as possible, to be ready before they are needed by the end-users, in this way effecting innovation.

Capacity building and competence development are central to the work funded in this KSA as, apart from natural attrition, the implementation of the NWA and all the changes that it implies to the management structures, requires that water management will be devolved to lower levels of government, requiring greater numbers of people who are able to fulfil the function.

TABLE 1

Overview and description of thrusts and programmes for the research funded within KSA 2

THRUST 1: ECOSYSTEM PROCESSES

Scope: This thrust includes research addressing the biophysical processes, form and function of ecosystems. This understanding will assist those managing the resource (water services, crop and aquaculture, biodiversity, etc.) to maximise socio-economic benefits in a sustainable manner. The aim is to generate knowledge to inform policy and management. Current programmes are:

Programme 1 Estuarine processes	**Scope:** Estuaries are fragile and highly productive ecosystems and are highly sought after as places to live. Projects in this programme address the ecological processes occurring in estuaries.
Programme 2 Riverine processes	**Scope:** Programmes to investigate the ecosystem functioning and processes of riparian zones, rivers and impoundments will be developed. This is an area in which South Africa needs improved capability to manage, and in the case of riparian zones, this is a topic attracting international interest.
Programme 3 Wetland processes	**Scope:** Within this programme research will be conducted to develop understanding of the ecological processes and functioning of wetlands, and assessing their value to both the catchment and the people living adjacent to them.
Programme 4 Groundwater-dependent ecosystems	**Scope:** Within this programme the dynamics of groundwater-dependent ecosystems will be investigated in relation to the aquifers on which they depend. This will be related to exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.
Programme 5 Impoundments	**Scope:** Research within this programme will cover ecological functions and processes within impoundments with a view to improving our ability to manage these.

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings. Current programmes are:

Programme 1 Ecological Reserve	**Scope:** Within this programme research will be conducted to develop and refine methods for determining and operationalising the Ecological Reserve as required by the NWA. The programme will address the more strategic issues such as the development of new and improved methods as well as the shorter-term issues such as implementation of the Reserve. This programme is managed in close association with DWAF.
Programme 2 Estuary management	**Scope:** Within this programme research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of government, communities) as management guidelines to inform them on how to manage estuaries sustainability. This programme is managed in close association with Marine and Coastal Management, DEAT.

Programme 3 **Ecosystem health**	**Scope:** The River Health Programme (RHP: custodians are DWAF, WRC and DEAT) aims to implement nationally (at the level of provincial government and industry) a coherent bio-monitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and so are kept in the same programme. Research on the environmental health of wetlands, estuaries and impoundments is also included in this programme. This programme links with the cross-cutting domain **Water and Health** and includes resource management actions which may affect human health.
Programme 4 **Environmental water quality**	**Scope:** Within this programme research will be conducted to develop bio-assays (both in the laboratory and the field) which will be employed to protect people and the environment from the effects of poor water quality. It will develop methods and competence to enable the use of toxicology in effluent discharge licences as well as its use in environmental water quality as required in the Ecological Reserve. This programme addresses the longer-term development and refinement of methods and the competence to use them, as well as the shorter-term competence required to implement policy in terms of the NWA. This programme links to the endocrine disrupter programme within the cross-cutting domain **Water and Health**.
Programme 5 **Endocrine disrupting compounds**	**Scope:** The overall objective is to characterise, and acquire information for assessing the EDC effects of various chemicals and compounds in water (singly or in combination) both those occurring naturally and those resulting from pollution which have the potential to cause detrimental health effects in humans, animals and the aquatic environment as a guide to develop and implement cost-effective treatment and control strategies. Further emphasis is on the development of simple, rapid and cost-effective detection techniques. This programme will be implemented in 3 phases, of which the first is already completed.
Programme 6 **Socio-economic considerations**	**Scope:** The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of Water-Linked Ecosystems with the ecological knowledge in order to develop the understanding and competence necessary to sustainably manage the aquatic environment.
Programme 7 **Ecosystem governance**	**Scope:** The overall objective of this programme is to an develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this.

THRUST 3: ECOSYSTEM REHABILITATION

Scope: This thrust addresses the rehabilitation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities with the view to restoring, as far as possible, process, form and function in order to provide the stream of goods and services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Capacity will be built to implement the research findings. Current programmes are:

Programme 1 **Wetland rehabilitation**	**Scope:** Within this programme research will be conducted to develop methods to rehabilitate wetlands which will address both abiotic and biotic components, and seek to rehabilitate ecological processes and restore biodiversity as far as possible in degraded wetlands. This will be done in terms of both the international conventions to which South Africa is signatory as well as recent legislation from both DEAT and DWAF. The programme will also develop the competence to implement rehabilitation. Projects in this programme link closely with each other, and are managed as a unit.
Programme 2 **River rehabilitation**	**Scope:** The research conducted within this programme aims to provide protocols for the rehabilitation of rivers, with the emphasis on urban rivers, that have been degraded as a result of anthropogenic activities or invasive biota.
Programme 3 **Influence of instream-constructed barriers**	**Scope:** This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems.

RESEARCH PROJECTS FOR 2007/08

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Development, testing and installation of a real-time Ecological Reserve implementation method for the Thukela River

Rhodes University, Institute for Water Research

No 1582

This project aimed to develop and test a real-time Reserve implementation method based on the Thukela River, and to install the system in the KwaZulu-Natal DWAF regional office. Previous experience on Reserve implementation had identified the need for suitable hydrological triggers to be used to specify the Reserve flows required in real-time. It also identified some of the limitations of the regional offices of DWAF to deal with, and make use of, the Reserve information supplied by the DWAF RDM office. Some concepts of how the triggers could be provided and how the implementation methods could be packaged emerged from the Thukela Reserve determination and were further explored by a previous **WRC Project (K8/510)**. Both of these projects concluded that the best method for low-flow management is likely to be based on the near real-time collection of rainfall data and the application of the Pitman monthly rainfall-runoff model. Further work is still required to address the issues of triggering high-flow releases from reservoirs to meet the high-flow requirements of the Reserve. One of the critical aspects of developing an implementation system is that it must be able to be used in practice and a major component of this proposed project is to package the range of estimation and modelling tools in such a way that it will be able to be used by regional DWAF water resource managers and later CMAs in the future. The developed tool will be generic and therefore applicable to other rivers where Reserve requirements need to be managed in real time.

Cost: R681 800
Term: 2005-2008

Programme 3: Ecosystem health

Evaluation of the fish assemblage integrity index to assess river health, and its refinement to ensure high levels of accuracy

Ecosun

No 1256

The Fish Assemblage Integrity Index (FAII) is a Rapid Bioassessment (RBA) protocol designed to measure the biotic integrity of segments of rivers based on attributes of the native fish assemblage.

This project aimed to evaluate the accuracy and precision of the FAII when used to assess site-specific impacts, recommend amendments to the techniques used and develop draft guidelines for the use of the FAII.

Three aspects were proposed as a bench-mark against which the FAII could be evaluated for site-specific application

- Conceptual – to evaluate the complexity and objectivity of the FAII
- Analytical – to evaluate precision and scale of the FAII
- Sampling – to evaluate accuracy, performance range and bias of the FAII.

Based on the results from the conceptual, analytical and sampling evaluations, it can be concluded that the FAII in its original format, would not provide results that are scientifically and thus legally defensible for use in site-specific evaluations. The main reason for this is ascribed to the high level of variability associated with the assessment of fish assemblages.

Cost: R593 00
Term: 2001-2005

Programme 4: Environmental water quality

Application of biosensors for eco-toxicity testing of water resources

University of Durban-Westville, Department of Microbiology

No 1286

The prokaryotic biosensors (simple organisms without a nucleus) were successfully freeze-dried using trehalose and Luria Bertani (LB) broth.

The data generated in this research demonstrate that these biosensors are potentially useful for the evaluation of environmental water samples and pollution management. Biosensors constructed in this study have the capacity to monitor environmental pollution. These whole-cell biosensors hold a great deal of promise for continuous on-line monitoring of pollutant concentrations in environmental applications.

Cost: R700 000
Term: 2001-2004

Programme 5: Endocrine disrupting compounds (EDC) in water sources

WRC Programme for EDCs

Consortium members: US, UFH, Technikon Free State, Tshwane University of Technology, SABS, CSIR Environmentek, ARC-PPRI, Consultant manager

No 1402 (includes Projects 1469, 1470, 1471, 1472 and 1473)

A limited surveillance study was conducted at 4 selected sites during 4 sampling events. The samples (water and sediment) were sent to different laboratories for activity testing and chemical analysis. These sites were selected at a workshop held in Stellenbosch during May 2003. The sampling events were chosen to cover the different seasons and rainfall events during 1 year. Ten samples were taken at different sampling points at each site during a specific sampling event. For activity testing some of the samples were combined because of the limited analyses capacity of the laboratories conducting these analyses. The hormone, mineral and pesticide analysis on the samples were done individually. Pesticide analysis on water was conducted by the ARC (PPRI), industrial chemicals and pesticides on sediment by the SABS and CSIR, mineral analysis by the ARC (IGWC), hormone analysis by AMPATH. Activity tests were done at University of Pretoria, CSIR (Environmentek) and University of Stellenbosch.

The results of the different laboratories participating in the study are summarised and presented. Water and sediment samples were analysed for pesticides, minerals and industrial chemicals. Hormone analysis was only conducted on water samples. Analysis of minerals was done on both water and sediment samples. Although only few minerals have EDC properties it is known that some of them have a synergistic effect with some pesticides.

EDC activity was detected at all the sites and the presence of EDCs was confirmed by chemical analysis. Hormones (estrone, ethinylestradiol and estriol) were found in water. Pesticides (endosulfan, terbutylazine, DDT and dieldrin) were found in low concentrations. Industrial compounds (p-nonyl phenol, phthalates and PCBs) were detected at some sites. All the individual reports of the participants are on the CD attached to the report.

No human health risk assessment was undertaken because there is not yet a model available for risk assessment of EDC pollution.

Cost: R3 000 000
Term: 2002-2005

A seasonal study of the endocrine disruptors in effluent coming from the Kuils River Sewage Treatment Plant, Western Cape, South Africa
University of the Western Cape
No 1590

Treated sewage effluents include natural hormones, synthetic hormones and hormone mimics and are therefore major sources of EDCs and have a major impact on aquatic and human health. Several man-made chemicals, also occurring in sewage effluents are known to be endocrine modulators that act by either enhancing, or interfering, with the actions of natural hormones in the body.

The aim of this study was to analyse sewage effluents from plants in the Western Cape to assess their contribution to EDCs in river water.
The following analyses were done:

- Extracts were assayed for oestrogenicity using an in vitro Xenopus laevis liver culture assay
- Human whole blood was cultured overnight in the presence of sample extract. The culture supernatants were collected and assayed for lactate dehydrogenase (LDH)
- Estradiol, estriol, estrone and testosterone levels in the sewage extracts were analysed using commercially available ELISA kits according to the manufacturer's instruction manual.

The different analyses were compared for sensitivity, cost and time needed to do the analyses. The concentrations of the major estrogenic compounds found in sewage effluent collected in the Western Cape, South Africa are similar to the levels found in Britain, Italy, Germany, Canada and the Netherlands. Due to the user friendliness of the ELISA methods, including the testosterone, for screening estrogens in environmental samples it is recommended that the method is included as an assay in the national toxicology programme.

Cost: R200 000
Term: 2005-2006

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Wetland rehabilitation
University of KwaZulu-Natal (lead agent),
Consortium: School of Life and Environmental Sciences
No 1408

Three main branches of research into wetlands were identified during a workshop held in early 2002, wetland rehabilitation, wetland health and integrity and wise use of wetlands. The wetland rehabilitation was prioritised for two reasons. Firstly, it is estimated that South Africa has lost approximately 50% of its wetlands, and wetlands are increasingly being recognised as providing valuable services. And secondly, there has been substantial government expenditure on wetland rehabilitation through the Working for Wetlands project, which is linked to the Expanded Public Works Programme. This project was co-funded by Working for Wetlands to 50% of the budget.

The 6 main objectives were:

- Prioritisation of wetland areas for conservation and rehabilitation
- System rehabilitation
- Methodologies for rehabilitation
- Synergy with other programmes
- Institutional arrangements
- Performance auditing.

These have been addressed in a series of 10 reports, and the titles and a brief overview of the contents of each are given below:

1. *WET-RoadMap: A Guide to the Wetland Management Series* (At this stage only the 1st Volume: WET – RoadMap is available for distribution)

Volumes 2-11 to follow:

2. WET-Origins: Controls on the Distribution and Dynamics of Wetlands in South Africa
3. WET-Management Review: The Impact of Natural Resource Management Programmes on Wetlands in South Africa
4. WET-RehabPlan: Guidelines for planning Wetland Rehabilitation in South Africa
5. WET-Prioritise: Guidelines for prioritizing Wetlands at National, Regional and Local Scales
6. WET-Legal: Wetland Rehabilitation and the Law in South Africa
7. WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by Wetlands
8. WET-Health: A Technique for Rapidly Assessing WET-Health
9. WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation
10. WET-RehabEvaluate: A Manual for the Performance Evaluation of Wetland Rehabilitation Projects

This series of documents provides all the information that is needed for the rehabilitation of wetlands, either for a programme such as Working for Wetlands or for private land owners who wish to monitor the state and/or rehabilitate wetlands on their property.

Cost: R4 000 000
Term: 2003-2007

Programme 3: Influence of instream-constructed barriers

Facilitating the free passage of migratory aquatic biota in South African rivers
Consortium: Pulles Howard & de Lange (lead agent)
No 1409

Current fish-way designs, worldwide, are very long to allow a full range of fish sizes to make use of the fish-ladders. This makes them expensive to construct.

An innovation was proposed by 1 of the contractors of the consortium for the design of a double (twin-channel) vertical-slot fish-way, allowing for a shorter fish-way with a steeper gradient (1:5) which would be more cost-effective but still intended to cater for all sizes of fish. It can be used on the back of gauging weirs or applied cost-effectively in other situations where fish-ways are required. Tests carried out at the hydraulics facility of DWAF and in the field have shown that the design does work. Currently the design is being incorporated into 2 Crump weirs being built by DWAF in the lower Vaal and middle Orange Rivers. WRC **Report No KV 197/07** includes details of both the design and the tests.

The major outcome of the research projects on fish-ways is published as *Guidelines for the Planning, Design and Operation of Fish-Ways in South Africa (TT Report No 287/07)*.

Cost: R2 000 000
Term: 2003-2007

CURRENT

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Biochemical processes in a groundwater-fed inter-tidal ecosystem: Biogeochemical controls on the plant biodiversity within a salt-marsh ecosystem in the West Coast National Park: Impact of saltwater-groundwater interaction on pore water chemistry and vegetation
University of Cape Town, (Department of Geological Sciences)
No 1591

The relationship between groundwater and surface water is poorly understood and the relationship between groundwater and the marine environment is even less well understood. However, the impact of poorly managed groundwater exploitation on the latter would have a severe impact on the ecology of the system. The groundwater – seawater mixing process impacts the salinity, anoxia and water movement, bioturbation and nutrient availability in the sub-surface coastal environment thereby controlling the distribution of halophytes and

freshwater loving plants and any change in this balance will reverberate through the ecosystem. Over-exploitation of the groundwater resource will have this effect.

This project aims to investigate this relationship in the West Coast National Park, an area of low rainfall and permeable geology where the Langebaan Lagoon, which is primarily a groundwater-fed estuary is situated. The area is undergoing development and so the demand for exploitation of the groundwater is increasing. This research will refine the understanding of the groundwater discharge around Langebaan, generate water quality maps, and identify any relationship between plant species and geohydrological characteristics. It will also identify specific characteristics which may be used in a monitoring programme and make recommendations on environmental water requirements of the area.

Estimated cost: R397 400
Expected term: 2006-2008

Programme 2: Riverine processes

Habitat, use and movement of freshwater fish species
University of Cape Town, Freshwater Research Unit
No 1483

This project presents a unique opportunity to investigate the movements of large fish in an un-impounded river, the Doring River in the Western Cape. This is knowledge which cannot be obtained from elsewhere in the country as there are so few un-impounded rivers remaining. The two things making this opportunity unique are that the Doring River, which is one of the last un-impounded rivers in the country, will be impounded within the next decade or so, and that we have a researcher capable of the task. DWAF have asked for information on the movements of fish in a river system for use in their planning of fish-ways, and this research will complement the existing projects researching fish-ways by providing additional information that these projects will not be able to provide. This work has previously been funded as a consultancy, and progress has been made in both initial aims of the project, as well as in the sourcing of funds for the radio telemetry tracking of the fish.

Estimated cost: R688 000
Expected term: 2004-2007

Periphyton flow dynamics
University of Cape Town, Zoology Department
No 1676

Periphyton (benthic algae) in rivers is highly sensitive to changes in both water quality and flow. Periphyton forms the base of the riverine food chain and any change at this level will be reflected throughout the ecosystem. In addition, the growth of undesirable periphyton can have negative economic consequences in several ways. Filamentous algae can clog irrigation and water purification equipment as well as rendering the habitat unfit for sensitive organisms, blue-green algae can cause toxin, taste or odour problems and any excessive algal growth will reduce the recreational value of the water body. Knowledge of the dynamics of the relationship between water quality and flow on the one hand and the response of the periphyton on the other will enable more accurate prediction of this response, and this capability is required in the determination of the Ecological Reserve.

During this project understanding of the interrelationship between periphyton growth and water quality/flow will be developed to a point where preliminary predictions can be made, and this knowledge will be transferred to managers involved in determination and implementation of the Reserve.

Estimated cost: R1000 000
Expected term: 2006-2009

Programme 3: Wetland processes

National Wetland Rehabilitation Programme: Phase II – Wetland Health and Integrity
University of Cape Town, Freshwater Research Unit
No 1584

This is a solicited project, the second of three phases in the National Wetland Rehabilitation Programme, and focuses on the development of methods to assess the health and integrity of wetlands, as this assessment lags behind the assessment of rivers and estuaries, which poses a problem in the environmental water determination process.
There is growing recognition of the important role of ecosystem services provided by wetlands. This project will develop a suite of assessment techniques not only to assess the ecological condition of the wetland, but also the state of the services delivered, in addition to a protocol by which the loss of wetland function through degradation can be measured. Training courses and a communication programme will assist in the transfer of the technologies developed.

Estimated cost: R3 450 000
Expected term: 2005-2009

Programme 4: Groundwater-dependent ecosystems

Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa
University of North West (Potchefstroom), Zoology Department
No 1586

Ninety-seven per cent of the world's freshwater is subterranean, and there is an increasing demand for the development of this resource to meet the increasing needs of the population. Little is known about the stygobiont fauna or the interaction between underground and surface water. During this project the following aims will be addressed:

- Formulate a framework to characterise the geological occurrences and geographical distribution of the subterranean amphipods using GIS techniques
- Discussion on the applicability of the sampling protocol
- Identifying microbial composition in association with stygobiont amphipods
- Trace of inorganic macro-elements for water quality
- A primary framework development for the characterisation of groundwater systems.

Estimated cost: R1 350 000
Expected term: 2005-2010

Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa
North West University, Zoology Department
No 1586

Groundwater ecosystems are virtually unknown in South Africa. However, in Australia recent research has shown them to be highly diverse. Fundamentally, they are of interest because there are certainly organisms which will be new to science, and the physiology and food chain dynamics of the organisms inhabiting these areas is of interest. In terms of the new legislation on biodiversity it is necessary to protect the ecosystems. However, the introduction of the concept of a groundwater reserve in the Water Policy means that if we are to implement the policy effectively we need knowledge of the ecosystem that is to be protected.

The objective of this study is to broadly characterise the ecosystem in which stygobiont amphipods occur, develop a sampling method and conceptualise a biomonitoring protocol for groundwater using stygobionts.

Estimated cost: R1 350 000
Expected term: 2006-2009

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Environmental water requirements in non-perennial systems
University of the Free State (Centre for Environmental Management)
No 1587

Methods for the determination of environmental flows for the Reserve have been developed and used for rivers with permanent flow. However, many rivers in the semi-arid west of the country are ephemeral. The NWA requires that the Reserve be determined before licences may be issued, and currently used methods have not been verified for ephemeral rivers. Verification needs to be done and, where necessary, new methods.

Estimated cost: R2 737 000
Expected term: 2005-2008

Programme 2: Estuary management

Valuation of estuary services in South Africa
Nelson Mandela Metropolitan University, Department of Economics
No 1413

Estuaries are delicate systems that are not only in high demand for development, but also deliver important goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological processes and functions, but does not adequately account for the values placed on estuaries by people.

This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 170 000
Expected term: 2004-2008

The freshwater requirements of temporarily open/closed estuaries on the South Eastern and South Western Cape coasts
South African Institute for Aquatic Biodiversity (SAIAB)
No 1581

This project is the result of recommendations of a CERM strategic planning meeting held in March 2004 and is a multi-faceted project in order to answer the generic questions routinely posed during DWAF RDM workshops.

The outcome of the research will deepen the knowledge on the functioning of temporarily open and closed estuaries. The results will be worked into estuary management as the work progresses as the team are involved with DWAF and MCM initiatives in estuary management, including determination of the Reserve.

Estimated cost: R1 753 000
Expected term: 2005-2008

CERM: East Kleinemonde Estuary modelling study
Anchor Environmental Consultants; University of Cape Town, Zoology Department
No 1679

This project will be closely linked to WRC **Project No. K5/1581 (The freshwater requirements of temporarily open/closed estuaries on the South Eastern and South Western Cape coasts**), where the objective of this study is to integrate the knowledge generated in such a way as to provide the additional dimension of an economic evaluation of the estuarine services. In this way the knowledge generated will become more accessible to managers.

Estimated cost: R644 500
Expected term: 2006-2009

Programme 3: Ecosystem health

Osmoregulation in freshwater invertebrates in response to salt pollution
Rhodes University, Institute for Water Research
No 1585

Salinisation is a major cause of water quality deterioration. Current methods for water quality assessment include boundary values for specific salts. Biological data is scarce for most of these salts, and what exists is based on acute toxicity data. This research aims to provide chronic toxicity test data for selected indigenous stream organisms which is biologically relevant for the country. This will be done through physiological experimental research (oxygen consumption and osmolarity) using samples generated during acute and chronic toxicity testing, and evaluating the salt boundary values in the setting of resource quality objectives.

Estimated cost: R2 01 160
Expected term: 2005-2007

The effects of streamflow manipulation on the intermediate hosts and vector populations of disease and the transmission of associated parasites
Environmental Assessment and Reporting, Institute of Natural Resources
No 1589

An effect of manipulating the flow of a river is that the changes in habitat will result in changes in the occurrence, population dynamics and dominance of organisms in the ecosystem. While many of the effects brought about by these changes are known, one effect which needs more attention is the influence of flow manipulation on the aquatic intermediate hosts/vectors of the diseases. The diseases caused by bilharzia, liver fluke and malaria are prevalent in certain areas of South Africa and within these areas are considered to have important economic consequences, which are manifest in sectors of the economy other than the water sector. The implication of the Reserve process determination on human health has hitherto not been realised or researched. The need to understand the relationships between the environmental Reserve and epidemiology is critical for community household health and regional economic growth. This project will define the intermediate hosts/vectors and routes of parasite transmission in the natural environment for bilharzia, liver flukes, and malaria; describe those streamflow interventions that enable or enhance the intermediate hosts/vectors life cycle and parasite transmission; it will assess the low manipulation options for control of the Intermediate hosts/vectors and associated parasites. The project will develop the capability to predict the effect of flow manipulations on the intermediate hosts/vectors and associated parasites and will make recommendations on how streamflow manipulation could be used to manage the incidence of the identified diseases.

The project will be carried out mainly as a desktop study and available data from the regulated and unregulated rivers will be considered. Relevant case studies that illustrate the implications of streamflow regulation for regulation of intermediate host/vector populations and the transmission of associated diseases will be identified for use in this study.

Estimated cost: R400 000
Expected term: 2006-2008

Conservation model for threatened fish species
Limpopo University, School of Agricultural & Environmental Sciences, Aquaculture Unit
No 1677

Freshwater ecosystems are recognised as the most threatened ecosystems worldwide, and in an inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of

habitat, are generally more sensitive to disturbance than invertebrates. The 3 main threats are from habitat loss, impact of aliens and exploitation.

The objective of this project is to develop a conservation model for threatened fish species using Opsaridium peringueyi as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170
Expected term: 2006-2008

Programme 4: Environmental water quality

A programme for research into the application of aquatic toxicology to water resource management
Rhodes University, Institute for Water Research and Ecosun
No 1313

This toxicology programme will investigate the application of aquatic toxicology to water resource management. The specific aims were determined at a workshop held early in 2002 together with DWAF.

Estimated cost: R1 900 000
Expected term: 2002-2005

Application of chronic (sub-lethal) toxicity endpoints to the development of resource quality objectives
Rhodes University, Centre for Aquatic Toxicology
No 1484

It is necessary to know the chronic levels of a toxicant for the process to determine water quality in the Reserve, so that safe levels may be prescribed. This project will refine work on acute toxicity of various stressors in order to verify extrapolations of chronic toxicity levels to acute levels.

Estimated cost: R1 340 000
Expected term: 2004-2007

Determine the applicability of ecological informatics modelling approaches for South African conditions with preliminary testing on algal blooms
University of the North West (Potchefstroom), School for Environmental Sciences
No 1675

Ecological informatics was formalised as a discipline in 2004 and is defined as an interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing at and between all levels of complexity of ecosystems for use as a decision-making tool. Cyanobacterial blooms pose an ongoing problem in the water treatment industry, and there is currently no way of forecasting events, with planning being based on past experience. The ecological informatics approach is being developed, with some early success, for the forecasting of cyanobacterial blooms in Australia.

The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use based on the technologies used in Australia for use by water resource managers and water treatment works.

Estimated cost: R225 000
Expected term: 2006-2007

Programme 5: Endocrine disrupting compounds (EDC) in water sources

An investigation into the occurrence of steroidal hormones (oestrogens) in sewage effluent using biological/biochemical and chemical techniques
CSIR Environmentek
No 1555

Chemicals with endocrine disrupting potential find their way into the environment via use and disposal. A large number of structurally diverse chemicals are suspected to act as EDCs. One of the groups of EDC contaminants found in the environment is the steroidal hormones (oestrogens). Studies have shown that sewage effluent and surface waters contain the oestrogenic chemicals 17ß-estradiol, estrone, estriol (metabolites of human hormones) and 17α-ethynylestradiol (synthetic oestrogen). Several in vivo and in vitro biological/biochemical techniques have also demonstrated significant oestrogenic activity in South African sewage effluent and receiving surface waters. As oestrogens may pose a risk to human health and aquatic life, it is essential to screen local sewage effluent for oestrogens, to ensure useful results for risk assessment and management.

The objective of this project is to determine the oestrogenic activity (biological/biochemical tests) and oestrogen concentrations (chemical analysis) in the effluent of selected sewage treatment works.

Estimated cost: R120 000
Estimated term: 2004-2005

An investigation into the occurrence of EDCs, organochlorine pesticides and heavy metals (Cd, Zn, Ca and Pb) in surface waters of the Northern Province
University of Venda
No 1557

Organochlorine pesticides (OCPs) and cadmium (Cd), a heavy metal, have been implicated in endocrine disrupting activities. Lead (Pb) though not classified as endocrine disruptor is equally toxic. In malarious regions residual spraying of DDT for malaria control purposes is common and allowed by government. OCP residues could get into freshwater systems via stormwater erosion (both urban and from agricultural lands). OCPs have been of great concern due to their persistent nature and chronic adverse effect on wildlife and humans. These substances including Cd may affect the normal function of the endocrine systems and can adversely affect the bio-diversity of the ecosystem and also have serious implications for human health. Cadmium is also implicated in endocrine disrupting activities. Lead is also shown to be toxic. Zink (Zn) and calcium (Ca) have synergistic and antagonistic interactions with Cd, respectively. Their presence in large amounts could affect the toxic effects of Cd one way or the other.

Water quality criteria for Cd, Zn and Ca have been set, but have not been established for other EDCs. DDT was detected in streams and some at levels marginally higher than the WHO guideline levels. It is important to widen the scope of the study to get a clearer picture of the pollution profile of waters in the Northern Province. The objectives of the project are to:

- Establish the use pattern of pesticides in the region
- Compile a list of endocrine disrupting pesticides in use and other potential EDCs and heavy metals (Cd)
- Determine the levels of OCPs and heavy metals – Cd, Pb, Zn, Ca (Ca & Zn because of their synergistic and antagonistic effects on Cd) in major freshwater systems in the region.

Estimated cost: R60 000
Estimated term: 2004-2005

The environmental exposure and health risk assessment in an area where ongoing DDT spraying occurs
University of Pretoria
No 1674

The presence of DDT and metabolites in single pilot water, sediment and fish samples from the Vhembe district, Thohoyandou, Limpopo Province, is of concern. The concordant high prevalence of urogenital birth defects and the DDE concentrations in cord blood in babies born in a DDT-sprayed area should be regarded as a matter of extreme concern. The research question is whether environmental levels of DDT and DDE may contribute to adverse health effects in catfish and may pose a health risk for humans. The project will review the effects of EDCs on aquatic invertebrates and develop a comprehensive research programme to investigate the use of aquatic invertebrates as monitors of ecological health effects of endocrine disruptors. A further objective is to link possible health effects in biota from a DDT-sprayed area to adverse health effects in humans living in the Vhembe area. A scenario-based health risk analysis will be performed, EDC assessment techniques evaluated

and a toolkit of tests for wider application in other spraying areas will be developed

Estimated cost: R1 985 000
Expected term: 2006-2008

Thyroid-disrupting activity in South African waters: Amphibian metamorphosis as biological model to study effects of endocrine contaminants on thyroid function
University of Stellenbosch, Department of Zoology
No 1680

Endocrine disruption of the control and functioning of the reproductive system is of global concern, but there is also evidence that EDCs may interfere with the normal functioning of the thyroid system. Changes in thyroid function could adversely affect several physiological systems in humans and wildlife but the specific effects and toxicants involved is not well known. This project aims to set up, validate and review protocols of the Xenopus metamorphosis assay (XEMA) for testing effects of water-borne chemicals on the thyroid endocrine system. A chemical and water serial diluter system and a flow-through water exposure system for EDC screening will be designed and tested.

Estimated cost: R400 000
Expected term: 2006-2008

Programme 6: Socio-economic considerations

Framework and manual for the valuation of goods & services of aquatic ecosystems for resource-directed measures
Zeta Consulting CC
No 1644

The determination of the Ecological Reserve for a particular catchment area requires the integration of the catchment area's management class, the related Reserve and the resource quality objectives. In addition, benefit trade-offs with other water users also have to be considered. The NWRS recognises this by seeking to find a 'balance between protection and utilisation'. Therefore, in order to develop resource-directed measures (RDMs) that are technically sound, scientifically credible, practical and affordable, a framework and manual for the valuation of goods and services from aquatic ecosystems for the RDM are now required. The set of problems to be addressed here is therefore clear: in order to enable interpretation (and negotiation) of the likely consequences of changes in management class as embodied in the RDM procedures, the 'invaluable' aquatic ecosystem threshold must be determined, while trade-offs in ecological, social and economic benefits of the other management classes must be made transparent to users and other interested and affected parties.

This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R750 000
Expected term: 2006-2008

Enriching freshwater conservation planning and management
CSIR Environmentek
No 1678

The pressures from social-economic aspirations have resulted in a progressive degradation of freshwater habitats in recent decades. As in other countries, this country's rivers have deteriorated faster than terrestrial habitats. *Ad hoc* conservation efforts are not effective in the face of this pressure; a strategic and systematic approach is needed if the initiative is to be effective.

This project is part of a suite of initiatives (funded by WRC, DWAF and CSIR) which include the development of cross-sectoral policy and planning tools for conservation planning, and aims to advance our understanding of the relationships between freshwater conservation planning and the socio-economic and political processes that govern freshwater conservation at international, national and sub-national levels. This will be done through engaging the broader socio-economic and political discourse to identify the issues that are important for the successful implementation of the conservation planning process, and incorporating these into the overall process. This will be tested in a specific geographic context.

Cost: R450 000
Term: 2006-2008

THRUST 3: ECOSYSTEM REHABILITATION

Programme 2: River rehabilitation

Integrated management of water hyacinth in South Africa
University of the Witwatersrand, School of Animal Plant & Environment Sciences,
No 1487

Water hyacinth is difficult to control and is a problem worldwide. Chemical control is expensive and ineffective in the long term. Biological control has provided a sustainable and cost-effective control in certain conditions, but the harsh South African winters are more detrimental to the control agents than the weed, allowing the weed to regenerate in the spring of each year. This project will refine earlier work (**WRC Project No K5/915**) to control this problem weed by low-dose levels of certain herbicides without unduly damaging the populations of the control agents.

Estimated cost: R1 655 600
Expected term: 2004-2009

NEW

THRUST 1: ECOSYSTEM PROCESSES

Programme 3: Wetland processes

To investigate the capability of the Mfabeni Mire (St Lucia) to respond to climatic and land-use stresses and its role in sustaining discharge to downstream and adjacent ecosystems
University of KwaZulu-Natal, School of Environmental Sciences
No 1704

The relationship between groundwater and surface water is important and not well understood. The Mfabeni Peatland (at 1 250 ha one of South Africa's largest and at ~45 000 years before present one of South Africa's oldest peatlands) is situated on the East shore of Lake St Lucia within the Greater St Lucia Wetland National Park. The water from this wetland flows into Lake St Lucia where it provides freshwater refugia for biota in times of drought. During times of climate change wetlands such as this will potentially become more important for maintaining the biodiversity of Lake St Lucia and other similar systems.

The research undertaken during this project will quantify the water balance of the peatland, the contribution of freshwater to Lake St Lucia and evaluate the effects of climate change and land-use on the water flux. Principles drawn from this work will increase understanding of the relationship between groundwater and surface water elsewhere and give guidance in managing this interface.

Estimated cost: R1 123 391
Expected term: 2007-2010

THRUST 2: ECOSYSTEM MANAGEMENT & UTILISATION

Programme 2: Estuary management

Estuaries and economic empowerment
University of KwaZulu-Natal,
Centre for Environment, Agriculture & Development
No 1705

Earlier phases of the East Cape Estuaries Management Programme researched the estuarine systems with the long-term aim of enabling communities living alongside the estuaries to generate income from the resource in a sustainable manner. Courseware was prepared and presented to local authorities (ranging from poorly to well

resourced) on estuarine planning and management with a view to including the estuary in the Integrated Development Plan (IDP) of the local authority.

This follow-up project will focus on subsistence livelihoods and will examine such issues as economic empowerment, institutional arrangements, participatory governance in the light of opportunities available, and will establish a framework where identified opportunities can be picked up in the IDP process. Principles developed during this suite of projects will be applicable to wetlands and other areas where natural resource-based enterprises may be developed.

Estimated cost: R1 500 000
Expected term: 2007-2010

Programme 3: Ecosystem health

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment
Rhodes University, Institute for Water Research
No 1706

Scientific research has shown that all major aquatic wildlife groups are experiencing endocrine disruption (ED). ED, at many sites, is caused by a complex mixture of substances, very often in low concentrations but acting in synergy with other compounds in the mixture.

Imperfect knowledge about the effects of EDCs on ecosystem structure has implications for environmental risk assessment for EDCs. An important emerging approach is to develop models for ED exposure in food chains, including pathways for human exposure. This study will research and design a conceptual risk assessment model related to the unique features of EDC dynamics in the aquatic environment in South Africa.

This project aims to assess the advances made in the development of ecological-based risk assessment models and the use of the precautionary principle (vs. weight of evidence) in ecological risk assessments, as well as associated data requirements, with particular reference to EDCs.

An appropriate ecological risk assessment model or framework for application in South Africa will then be recommended. The results will add value to the existing EDC programme and will provide guidance regarding future research.

Estimated cost: R1 099 415
Expected term: 2007-2009

Programme 4: Environmental water quality

Development of a diatom-based bio-monitoring protocol for South African rivers and streams. Phase III: Regional testing, method refinement & calibration; index formulation and river health programme
DH Environmental Consulting
No 1707

The study is an extension of 2 earlier phases (Phases 1 & 2) of the development of a diatom-based biomonitoring tool. The NWA ensures the protection of water resources, and therefore methods are needed to identify the health of aquatic systems. It is envisaged that the results from this study will be used in State of River reporting and will form part of the River Health Programme. The Diatom Assessment Protocol (DAP) as a biomonitoring tool can be used to test the water quality of various waterways, including the urban waterways. This study (Phase 3) will deal with the formulation and calibration of a Diatom Index for South Africa. Through testing of diatom species over a time period, the species that are most ecological important will be determined for use in calculations. This study will determine those important diatom species to develop a South African Diatom Index. A diatom-based index will be accepted by DWAF and key stakeholders as a biomonitoring tool related to the 6 (A-F) RDM water quality/condition classes. The objectives of the study are to:

- Formulate and validate a unique SA Diatom Index for rivers and streams related to the 6 RDM water quality/conditions classes
- Validate DAP methodology in close association with the ongoing development of the suite of aquatic ecosystem assessment models (VEGRAI, FRAI, GAI & MIRAI)
- Establish an inter-laboratory calibration and testing component for diatom identification
- Report on the modification of DAP for the rehabilitation of urban streams and canals with the inclusion of the DAP in the testing protocol
- Build capacity of scientists and DWAF personnel in the use of this tool in determining water quality and as a supplementary tool to determine the eco-status of rivers and wetlands
- Develop courseware for DAP for tertiary level education
- Report on river reference conditions based on historical diatom data.

Estimated cost: R1 824 450
Expected term: 2007-2010

Programme 5: Endocrine disrupting compounds in water sources

Environmental assessment in an area where ongoing DDT spraying occurs
Rhodes University, Institute for Water Research
No 1708

Previous research at Rietvlei Dam, (**WRC Project No K5/1505**) identified a number of possible EDCs. DDT was a major contributor in many of the samples analysed. In Limpopo Province and KwaZulu-Natal, DDT is used for malaria control, and higher environmental levels were expected in studies there.

This research will add value to the variables being investigated by **WRC Project No K5/1674** in the Limpopo Province. The data will also contribute to the risk assessment to be undertaken in the same area.

Several invertebrates and vertebrates will be examined for the effect of DDT:

- Snails have been identified as a promising endocrine disruption biomarker
- *Xenopus laevis* and other frog species will be collected at small ponds, and investigated for indication of endocrine disturbance, possibly related to DDT. 3
- Pied Kingfishers (*Ceryle rudis*) have been shown to be good indicators of aquatic pollution, and eggs will also be collected from other water birds as well from sparrows and this will provide an indication of the transfer of DDT from food and soil particles
- Small mammals (mice and rats as appropriate) will be collected and examined for EDC-induced abnormalities.

This battery of vertebrate and invertebrate indicators, (snails, frogs, birds, rats and mice), collected *in situ*, could provide further evidence for ED activity, and contribute towards risk assessment under locally relevant conditions

Estimated cost: R398 330
Expected term: 2007-2008

Programme 7: Ecosystem governance

Framework and manual for the valuation of goods and services from aquatic ecosystems for the resource directed measures (RDM)
CIC International
No 1644

Knowledge concerning the socio-economic aspects of sustainable ecosystem management lags behind knowledge of the ecosystem functions and processes. Insight and application of aquatic ecosystem valuation needs to be improved.

This project will investigate and develop appropriate techniques which will determine the value of aquatic ecological functions.

Estimated cost: R750 000
Expected term: 2007-2008

The development and testing of a coherent, integrated and practicable set of indicators for the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation
Association for Water and Resource Development (AWARD)
No 1709

Indicators provide a method for presenting information in a standard way that can be monitored and used to measure change. The wetlands in the communal areas are important resources which provide livelihoods for many of the poor people in the area. While the land tenure system in is not conducive to the exercise of close control of practices, these wetlands do form part of the national water resource and South Africa's IWRM policies require the integration of the many components of the water resource.

Research done in this project will develop and test a coherent and practicable set of indicators for an integrated approach to the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation. Specifically, generic indicators for successful and sustainable wetland management with a particular focus on communal wetlands will be developed. In addition, international indicators (e.g. poverty) that do not fit the RSA situation will be refined for use within the existing governance situation.

Estimated cost: R236 100
Expected term: 2007-2008

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity
CSIR – Natural Resources and the Environment
No 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision making in a situation of varying levels of certainty and of potential conflict.

Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820
Expected term: 2007-2009

KNP river governance
The Shared Rivers Initiative Phase 1: Part A – Contextual profiles of the shared rivers of the Kruger National Park
No 1711

Research undertaken during this project will address a recently identified gap in the governance process of water resources in that a formal route of response to the red flag raised when a Threshold of Probable Concern is exceeded during the Strategic Adaptive Management process needs to be defined.

There is growing concern among scientists, managers and the general public in South Africa about the continuing decline in the integrity of the river systems of South Africa's north-east Lowveld in spite of an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management.

The Lowveld river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland). Each has to achieve their own important resource management and water supply priorities within their portions of these basins. Each neighbour faces a similar set of needs and challenges in its attempts to balance social development imperatives with management for resource sustainability. There is a clear need to harmonise management and decision making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery.

This project aims to explore water policy implementation as a complex social-ecological and initiate an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management. During this process, an understanding will be developed towards managing the Lowveld rivers following a cooperative, international and basin wide approach.

Estimated cost: R1 500 000
Expected term: 2007-2009

THRUST 3: ECOSYSTEM REHABILITATON

Programme 2: River rehabilitation

The potential of food-web manipulation for the restoration of eutrophic South African impoundments
DH Environmental Consultants
No 1643

The project will address the challenge of eutrophication through the application of food-web manipulation as a cost effective management option for South Africa's indubitably most limiting natural resource – fresh water. Many South African waters subsist in an advanced state of eutrophication, viz. a plagio-climatic condition dominated by a few taxa of coarse phytoplankton and fish. Such systems are resilient to remediation and require shock treatments such as the rapid bulk removal of problematic fish to allow the system to reset. In South Africa, eradication of Common Carp was seen as the first step in rehabilitation of most dams with eutrophication problem because it is this alien fish that prey on zooplankton, feed on open waters among macrophytes, and contributes in sediment disturbance and water column turbidity. The project will develop a scientific understanding regarding the storage vessels (dams) that largely supply all water user sectors (industry, agriculture, and domestic supply). The aims of this study are to:

- Determine fish assemblages at a suite of impacted and control dams in the same eco-region, coupled with identification of trophic state and eutrophication impact assessment
- Determine harvesting requirements to reset the fishery to a desirable assemblage
- Determine harvesting requirements to sustain the desired assemblage
- Collect data on specific abiotic and biotic components (stable isotopes, phytoplankton and zooplankton assemblage)
- Compare and contrast commonalities of ecosystem response and degree of system (site) specificity
- Assess in broad terms, economic and financial implications of the recommended approach
- Identify constraints to the proposed rehabilitation methodology
- Evaluate the findings in terms of the potential of this approach as a method for impoundment rehabilitation, as well as for commercial opportunities.

Estimated cost: R1 727 760
Expected term: 2007-2009

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KSA 3: Water Use and Waste Management

Mr Jay Bhagwan | Director |
Water Research Commission

SCOPE

The **Water Use and Waste Management** KSA focuses mainly on the domestic, industrial and mining water sectors. It aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. This KSA also supports studies on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Research on infrastructure for both water supply and sanitation is included. A further focus is on water supply and treatment technology serving the domestic (urban, rural, large and small systems) as well as the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors with the aim of improving productivity and supporting economic growth while minimising the negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, becoming incrementally scarce. Managing water use and the waste released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it.

Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. A changing institutional environment and the need for strong institutional capacity exacerbate this challenge.

OBJECTIVES

The primary objective of this KSA is to provide knowledge that ensures reliable, affordable and efficient water use and waste management services to enhance the quality of life, and contribute to economic growth and improved public health.

The secondary objectives are to:

- Improve the management of water services in both rural and urban areas
- Develop appropriate technologies for improving the quality and quantity of our water supplies for both domestic use and industrial applications
- Develop new approaches to manage and enhance hygiene and sanitation practices
- Provide appropriate, innovative and integrated solutions to water and waste management in the industrial and mining sectors
- Develop applications for improved treatment of wastewater and effluent and improve processes for enabling increased reuse thereof
- Improve health, economic and environmental conditions, while supporting the development of appropriate technologies and socially-focused management practices related to water and effluent management.

THRUSTS AND PROGRAMMES

During 2007/08 no new programmes will be initiated. However, the following consolidation and changes will be effected in **Thrust 5: Sanitation and Hygiene Education:**

- **Programme 3 – Knowledge/information management and advocacy**, is being closed for the reason that the framework has been developed and future work in this area will overlap with the subject areas in **Thrust 1: Water services – Institutional and Management Issues**
- Similarly, **Programme 6 – Financial sustainability of sanitation services** is being closed, as much work has been covered and new initiatives overlap with the subject areas in **Programme 3 – Institutional and management aspects of sanitation services**
- Thus the new programmes in **Thrust 5** will be as follows:
  - **Programme 1 – Advocacy, health and hygiene education**
  - **Programme 2 – Peri-urban sanitation research**
  - **Programme 3 – Institutional and management aspects of sanitation services**
  - **Programme 4 – Technical sustainability of sanitation services**

This KSA focuses on a portfolio of 5 thrust areas, these being:

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability is key to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure management, operations and maintenance, sanitation (stormwater, sewerage and on-site sanitation), water-related competencies and capacity required for the strengthening of water institutions (water service providers, water service authorities, water boards, national departments) in providing sustainable water services.

Current programmes are:

- Cost recovery in water services
- Institutional and management issues – Water services
- Innovative management arrangements – Rural water supply
- Regulation of water services
- Impact of water and sanitation interventions.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of sufficient quality and quantity for domestic and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. Linked to water supply is the all-important aspect of the protection of human health. The objective of this thrust is to develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

Current programmes are:

- Drinking water treatment technology
- Water treatment for rural communities
- Drinking water quality
- Water distribution and distribution systems.

THRUST 3: WASTEWATER AND EFFLUENT TREATMENT AND REUSE TECHNOLOGY

Scope: With the continuous increase in wastewater and effluent flows, the challenge posed is how to better manage treatment, such that the effluent produced complies with legislative requirements and can be considered as a resource. Research in this thrust aims to develop innovative treatment technologies and systems that would optimise treatment processes and infrastructure in the municipal, mining and industrial sectors.

Current programmes are:

- Biological sewage treatment processes
- Sludge characterisation, treatment, utilisation and disposal
- Treatment and recovery of organics from agro-industrial processing
- Treatment and recovery of inorganics (including sulphate and metals) in industrial and mining effluents
- Training in wastewater treatment plant operation
- Biotechnological co-treatment of industrial/mining effluents with sewage wastewaters
- Sewerage reticulation
- Stormwater management
- Energy from waste.

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the industrial and mining sectors.

Current programmes are:

- Quantification of water use and waste production
- Regulatory mechanisms to improve industrial and mine-water management
- Minimising the impact of waste on the water environment
- Minimising waste production
- Improved ability to predict and quantify effects.

THRUST 5: SANITATION AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery beyond 2010. The focus is on low-cost and affordable sanitation technologies.

Current programmes are:

- Advocacy, health and hygiene education
- Peri-urban sanitation research
- Institutional and management aspects of sanitation service delivery
- Technical sustainability of sanitation services.

RESEARCH PORTFOLIO FOR 2007/08

The strategic focus of this KSA is guided by the technical, environmental, social and institutional challenges posed in the supply of water and the treatment and disposal of wastes (including sewage, effluents, polluted drainage and solid waste) in the domestic, industrial, commercial and mining sectors. A key consideration is to achieve integrated and holistic solutions that aid sustainable development. In the domestic sector, greater emphasis has been placed over the past few years on supporting water services issues, in order to accelerate service delivery and implementation of water services legislation. There is ongoing emphasis in this area on assisting and capacitating local government in the delivery and acceleration of services, education around sanitation and hygiene issues, and the promotion of sustainable solutions. In the industrial and mining sectors, the focus is on developing and promoting management systems, technology and process improvements which support greater efficiency in the use of material and energy resources and, hence, a reduction in pollution. While continuing to support the development and improvement of treatment systems for environmental and human protection, the emphasis is placed on convincing all sectors to recognise wastes as a resource and the processes for recovery and reuse as commercial opportunities. As in previous years the new portfolio of projects aims to continue providing solutions which support these directions in the following ways:

- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including grey water and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes.

Strategic initiatives of the previous years; the consolidation of research and project activities in the year 2006/07; the outcomes of the WRC Institutional Review; the needs identified by the Minister of Water Affairs and Forestry, as well as strategic engagement with the Department of Water Affairs and Forestry (DWAF) and other stakeholders have provided the path for strengthening the activities of this KSA related to strategic direction, technology transfer, project management and business processes towards meeting the KSA as well as the broader organisational goals.

The year 2007/08 placed greater emphasis on technology transfer and consultations with the sector role-players towards further identifying research needs and creating awareness of the strategic research portfolio for the KSA and its thrusts. This is in line with the recommendations emanating from the WRC External Review. Further, the portfolio of investment continues to focus on rural water and sanitation or development needs, with 2 out of the 5 thrusts dedicated to this area and at least an estimated 40% of the total KSA projects budget.

Twenty-nine (29) new projects have been accepted for funding, comprising 8 non-solicited and 21 solicited projects. An amount of R1 479 193 has been set aside to allow the KSA to respond to priority research issues requiring urgent attention which may emerge during the year.

BUDGET FOR 2007/08

The approved funding of the research portfolio for 2007/08 leads to a committed funding budget of R35 436 864. The focus of this portfolio will continue along the current trends.

CORE STRATEGY

Strategic context

No major changes with regard to water use have emerged over the past few years, except for the floods, Tsunamis and earthquakes that have raised greater concern as to how to deal with disasters and its mitigation, as well as coordinating strategies for restoring and rebuilding reliable water and sanitation provision. However, the aspect of global warming and its impacts on water use are continuing to achieve greater attention and priority.

Water is an essential ingredient for economic development, the maintenance of natural life support systems and basic human existence. Urbanisation and industrialisation rates in developing countries have escalated significantly over the last 20 to 30 years. Economic growth and development resulting in a greater demand for water and annual consumption continues to rise in most countries. Ensuring a reliable source of clean water and adequate treatment of wastes and wastewater for large urban populations and rural communities pose great challenges for many developing countries. South Africa is no exception to this situation and this has led the government to embark on major water-related infrastructure development projects and to introduce water conservation measures, the focus being on optimal utilisation of existing water resources, the upgrading of existing sources and the conservation and protection of catchment areas.

As water consumption continues to rise, government will face the huge challenge of meeting increasing water supply and wastewater treatment demands, together with overcoming a legacy of poor water resource management, the pollution of water sources and wastes. Only by developing long-term strategies to address these issues, including the introduction of water conservation measures and continued investment in water-related infrastructure, will access to clean water and treatment facilities be available to a greater proportion of the population in the future. It is clear that the cost of providing clean water to an expanding and growing population and growing economy will continue to increase.

Whereas the provision of water for human needs plays a cardinal socio-economic role in the upliftment of people and in promoting a healthy population, it is the industrial and mining sectors which play a primary role in the development of the South African economy and, hence, in the development of the country in terms of wealth creation, employment creation and export earnings. Sanitation and wastewater treatment are essential elements of maintaining a healthy environment for our population. Environmentally, the mining and industrial sectors have common features such as an intensive demand on material and energy resources, a major impact on the landscape, a relatively small demand on the national water use and a proportionately much higher pollutant profile. This includes effluents of high concentration, contaminants that are difficult or expensive to remove, and with the potential to degrade large volumes of water, thereby rendering them less fit for other beneficial uses. Effluents from all of these sources arise either as point sources (e.g. piped effluents from factories or sewers) or as non-point sources (e.g. runoff from un-serviced high-density settlements and seepage from mine slimes dumps or mine workings).

Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as our environment. The entire way we think about and use water is thus an important aspect in determining our future.

When comparing water use against the growth domestic product (GDP) of South Africa, the example of Gauteng shows that for an estimated use of 11% of the total water used in South Africa (1 355 million m^3/annum), Gauteng generates 38% of South Africa's GDP and 10% of Africa's GDP (DWAF 2004, Gauteng Water Summit).

Although the water requirements for domestic and urban (23%), industrial and mining (6%) sectors are a fraction compared to total water availability and water consumed, it is the assurance and continuation of the supply that dictates the high capital and infrastructure costs. Industrial and mining processes, though a small user of water, together contribute to the bulk of the pollution affecting our water environment.

The policies of the previous government has left a legacy which has resulted in at least half of the population of South Africa not having access to safe and reliable water services. The current government has made this the focus of attention since 1994 and great strides have been made in improving this situation. The radical policies and strategies that have been introduced to accelerate and achieve the goal of complete coverage has generated and posed a number of new challenges on the issue of sustainability of water services.

The costs of providing clean water and sanitation to a fast-expanding and growing economy will continue to escalate. In an environment of increasing resource and financial constraints, coupled with the vision of some for all and the need to redress past imbalances, efficient use of water for domestic, industrial and mining purposes, as well as improved sanitation, would be critical for improving public health, eradicating poverty and contributing to global competitiveness.

To achieve this more innovative policies and improved implementation strategies for water use and waste management will be required, supported by a strong basis for appropriate technologies, changes in infrastructure approaches and broader water management policies. It is inherent that institutional processes and capacity be in place, supported by sound technologies and methodologies.

Over the past 30 years, the science of water supply and collecting, treating and using wastewater and stormwater beneficially has grown significantly. As a nation we have gone from rudimentary treatment to complex systems involving multiple phases and types of treatment. We have also expanded considerably the infrastructure of collection systems feeding increasingly sophisticated treatment plants. However, much still needs to be done. As water and wastewater flows continue to increase, supply and treatment systems must be optimised for better management and efficiency. This can be achieved not only by increasing infrastructure, but by finding new and innovative technologies and processes that will enhance the performance of systems. An example is treatment processes that can target development of new media and increasing treatment flow-through. New innovative and appropriate technologies will play a key role in the improved management and extension of our water resources.

With all the achievements and developments to date, it is clear that South Africa has amassed a substantial knowledge base and the competencies required to face the future challenges. There is a need to develop greater environmentally sound technologies and processes that command greater integration in the solutions they provide. A more holistic and integrated approach is required towards providing sustainable solutions focusing on aspects related to the participation of society, the impact on the environment and resource base, institutional and management issues, minimisation of wastes and other emerging issues.

Against this background the challenges posed are medium to long term and require greater interdisciplinary solutions. In line with the strategic context presented in previous years, which has regularly undergone both internal and external Reviews, there are no major changes, but there is greater emphasis towards solving the water supply and sanitation problems. It is noteworthy that the importance of research and development has also been strongly emphasised.

Needs analysis

This KSA in its endeavour towards identifying research needs, as well as developing and improving research strategies at the thrust level, has continuously engaged at a strategic level both nationally and internationally, to identify any gaps and strengthen the portfolio of priority research topics and areas requiring attention. In this regard, a number of small projects were awarded and the outcomes will provide the following:

- The state of stormwater management in South Africa
- The state of sewerage in South Africa
- The state of ponding and small wastewater treatment systems in South Africa.

Also in direct response to the national S&T strategy, the KSA has taken proactive steps in key areas in support thereof, as follows:

- In the area of biotechnology, greater emphasis has been placed on the biological treatment of wastewater and reuse. Our proactive approaches are leading towards cutting edge technological developments. Examples of these are the further improvements to the BioSure™ and Petro™ processes, biotechnological treatment of olive refinery wastes which, incidentally, also has the potential to be applied in other food manufacturing environments
- Scoping studies to investigate the use of nanotechnology in water
- Scoping studies to investigate alternative energy and biofuel potential from wastewater and sludge.

During the year 2007/08 strategic engagements with the Minister of Water Affairs and Forestry and DWAF highlighted the topics requiring attention related to fluoride in water, regulation of water institutions, servicing informal settlements, implementation challenges of policy and strategies, water efficiency and demand management. Similarly, the External Institutional Review of the WRC also highlighted that the WRC has made great strides in shifting the research agenda of the organisation to meet the immediate needs of society. However, it was felt that greater application was needed.

Added to the above, the following strategy was developed during the year that assisted to shape the KSA portfolio:

- Towards a research strategy and agenda to support water treatment and distribution in South Africa

In reviewing the wealth of information generated through the various processes of needs analysis, consultation with DWAF and other stakeholders, the WRC External Institutional Review and some of the incidents (such as the typhoid outbreak in Delmas; drinking water quality issues; and failure of many municipalities to provide basic services), it is clear that the key challenges facing the water sector in South Africa as identified last year remained unchanged and warranted greater emphasis and support. We believe that our strategy and focus are in line with supporting government's long- and short-term objectives, and especially those of Asgisa (Accelerated Strategy for Growth in South Africa). These being:

- In a changing and dynamic legislative and strategic environment many solutions are required for sustainable and affordable water services provision. A key focus over the next few years will be on strengthening the capacity of local government to function in this challenging environment, introduction of successful models of service delivery which enjoy the support of all stakeholders, tackling the issue of poverty and service provision (including affordability and cost recovery), development of appropriate strategies, tools and policies to regulate water services and give effect to the Water Services and related legislation. The aspects of community participation and local economic development are central to these objectives.
- The realisation of the challenges of meeting the MDG targets, and in the case of South Africa, meeting the backlogs set by government by 2010.
- The water services environment is in a continuous process of dynamic change. The newly published related legislation, besides setting a new set of challenges and goals for the sector, has reached a point of review. It will be imperative that the success of these frameworks and legislation will realise the ultimate goal of national water policy and local government legislation.
- Since 1994 greater emphasis has been placed on improving water supply coverage, resulting in sanitation coverage lagging behind. Recent incidences of cholera and typhoid outbreaks and the situation regarding the immune compromised have highlighted the importance of sanitation and hygiene. The provision of sanitation is more complex and provides greater challenges as the responsibility is spread across many government departments. The short-, medium- and long-term goals are to find effective and efficient mechanisms to accelerate sanitation and hygiene education coverage. These 2 components are essential ingredients for sustainability and achieving public health objectives. Focus areas over the short term are to develop appropriate technical solutions, finding ways to cost-effectively provide high-impact hygiene education, finding acceptable and affordable service arrangements, models for sanitation delivery and O&M, improving the legislation and policies that contribute to an enabling environment and accelerating sanitation delivery.
- The sustainability of low-cost and onsite sanitation systems is already beginning to surface. Short design life, pit emptying, relocation and access to pits are some of the key technical challenges which may jeopardise achievements made to date and the provision of sustainable sanitation.
- It is evident that new issues in water supply (water treatment, distribution, etc.) will continue to emerge as new contaminants are introduced into the water sources. Great challenges also exist in providing sustainable and affordable technical solutions for the poor and indigent sections of the population.
- In water supply and treatment technology, the needs over the next few years revolve around the supply of more affordable water of improved quality, especially to those people who do not yet have a reliable drinking water supply. Specific issues and research needs include the reduction in cost of water treatment and supply; the removal of organic contaminants; the removal of Cryptosporidium, Giardia and other pathogens; safe and efficient water fluoridation; improvement in the cost efficiency and sustainability of small- to medium-sized water treatment plants; dependable and efficient distribution systems; cost-effective distribution systems for rural water supply and sustainable and low-cost small water treatment systems. Medium- and long-term goals are to focus on infrastructure and asset management.
- Most of the country's industrial and mining activities are concentrated in areas where there is a lack of water resources. These sectors generate large amounts of wastes (toxic and non-toxic), which have a profound impact on the ecology of the receiving water environments. As urbanisation and industrialisation increase, increasingly complex wastewater streams are introduced. It is imperative that solutions are generated to manage these negative impacts. Furthermore, there is growing recognition for more innovative approaches such as cleaner production and waste minimisation. These areas require greater research support for knowledge generation and application.
- The mining industry presents additional needs that emanate from its legacy of water quality-degrading waste that has been accumulating for more than a century, and which could potentially affect water quality for future generations. In the case of gold mines these needs have to be addressed with urgency, as many mines are

about to close down, which may represent lost opportunities to introduce pollution-prevention measures. Key areas to be addressed include the process of acceleration of cleaner production and waste minimisation technology and the development of innovative solutions, to deal with the legacy of waste and acid mine drainage potential that has accumulated as a result of mining activities.

- There is a need for improving institutional capacity in the management of water and wastewater problems, as it has become increasingly clear that these problems cannot (in the South African context) be solved by technical solutions alone. Institutional reform and strategic management issues (such as regulation, capacity, competencies, partnerships, tariffs, community participation, etc.) all play an equivalent role in achieving an integrated solution. Great strides in information gathering and knowledge generation and application are required in this area over a short period.
- Over the past few years great strides have been undertaken in covering water and sanitation backlogs resulting in significant achievements. This has also resulted in the expansion and growth in infrastructure in urban and rural areas. More small schemes have come into existence and from international and local experience; they pose greater challenges in their sustainable management.
- Furthermore, the infrastructure and associated resources are the assets of our country and contribute to improving the quality of life and these need to be managed effectively. Lack of attention over the past few years on O&M, together with the lack of training and capacity is beginning to show its weaknesses in the state of our water infrastructure. This valuable investment, if not given due attention, could prove costly for the country.

Overview of technological trends

At an international level there is a continuous move towards new approaches as to the provision of water services and adaptation of new approaches to improved domestic water quality and improved availability of water through alternative advanced technologies. An emerging trend in developing countries is to decentralise the management of services to a local level or to a local government level, with the national authorities moving into a stronger regulatory environment. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries when there is the need to address the plight of the poor and indigent who make up a large portion of the customer base. Thus, innovative institutional arrangements and partnership models between public/private/community are being investigated to provide optimum solutions. Specifically in Africa, the issue of capacity and competency requirements, technology choices, institutional arrangements and costs and affordability are key areas of activity. Outcomes from the WSSD have highlighted the slow pace of water and sanitation delivery, and specifically sanitation, which is lagging further behind and the World Summit and World Water Forum 4 impetus on setting water and sanitation targets, has generated a new urgency and priority to this area of activity. South Africa's ambitious declaration of obtaining full coverage by 2010 has prompted greater importance to the provision of water and sanitation. There is a new drive to accelerate sanitation and hygiene education delivery and radical new policies and strategies are being investigated to achieve the millennium goals. It is essential that these concepts and ideas be translated at a local level; thus requiring the need for developing improved strategies, policies and mechanisms that create a sustainable and enabling environment.

In water supply, the emphasis is on efficient use of water and managing demand, as well as looking at the contributory elements such as energy, pipe components and materials, water supply components and behavioural aspects. In terms of treatment technology, the current international trends are toward the increased removal of more specific contaminants in the water. In addition, it is aimed at adding fewer chemicals to the treated water product (improved source quality). The removal of pesticides, heavy metals, endocrine disruptors, disinfection by-products and other harmful organics is receiving attention. The removal of *Cryptosporidium and Giardia* and the use of membrane filtration in this regard are receiving much attention – especially in the USA. There is a strong trend towards improving determination techniques of these new emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues on breaking the transmission of water and faecal-oral related diseases through understanding practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

In the developed world, there is greater attention and focus being placed on managing source quality for improved potable water quality. Secondly, as desalination technologies become cheaper, we see more use of these technologies (Singapore/Middle East are examples). This source of water is also seriously being considered by some South African coastal cities. Further to the concerns of the diminishing levels of fossil fuels, water and waste are being looked at amongst the renewable resources for energy creation.

Greater attention is also being given new promising technologies such as nanotechnologies, membranes etc. as they may greatly benefit water treatment technology.

In both the municipal and industrial sectors, the most significant trend internationally, nationally and at local authority level has been the growing realisation of recognising effluent wastewater and wastes as a resource. The treatment of wastewaters and wastes that have been generated without the application of cleaner production and waste minimisation principles is a losing game, ultimately costing all the parties material and energy resources, i.e. money. The consequences are profound: co-regulation becomes a meaningful negotiation; value as co-product is extracted from 'wastes' before discharge, thereby further reducing the waste load requiring treatment; technologies for treatment aim at being 'cleaner', are more focused towards specific waste fractions or even constituents and include recovery and reuse where technically and economically justifiable; resource-efficient technologies are not only favoured, but even their optimum deployment ('where' in the process stream) is critically examined, etc. These trends are predicted to not only continue, but, in fact, to accelerate in the future.

The mining industry has yet to embrace these new realities, and wastewater and waste treatment in this sector presently continues to be material (e.g. chemicals) and energy intensive, although more environmentally-friendly solutions are increasingly favoured, for example biotechnological treatment of acid mine drainage associated with potential recovery and reuse of the renovated water for a variety of purposes. The cost-effectiveness of cleaner production technology is increasingly recognised and will in itself be a strong driving force for the accelerated introduction of the technology. Another driving force is the international trade sanctions that are increasingly being applied against manufacturers that do not apply responsible environmental practices. In South Africa, it is foreseen that the introduction of waste discharge charges will be a further powerful driver towards internalising pollution costs and implementation of cleaner technology.

The contribution of mining-related non-point sources to water quality degradation is increasingly appreciated and has given rise to a need for improved techniques with which to quantify their contribution and improved technologies to minimise their effect.

Key stakeholders

The WRC is an instrument of government, thus making the Minister of Water Affairs and Forestry the main shareholder and DWAF its key stakeholder. However, the following stakeholders also continue to

be of key importance and important to the WRC in general and this KSA in particular. They are divided into internal and external stakeholders. Over the years, our international partners and business partners have also proven valuable to us.

The internal stakeholders are the WRC personnel, Executive Management and the Board.

The external stakeholders include:

- Government departments and the Ministers representing them (DWAF, DEAT, DPLG, DoH, Mineral and Energy, etc.)
- Advisory groups
- Beneficiaries (i.e. the users or potential users of research, development and knowledge products produced through WRC funding)
- SALGA, local government, provincial government units
- Development Bank of Southern Africa
- Water boards, water services providers, catchment management agencies, water user associations
- Industrial sectors and industry-representative bodies (mining, forestry, water services, etc.)
- NGOs, CBOs and international aid agencies
- Private consultants
- Tertiary institutions, primary and secondary education institutions, science councils, professional bodies (WISA, SAICE, IMESA, etc.) media agencies
- The public
- International coalitions such as GWRC, WSSCC, WUP, ET, UNEP, IRC, WARFSA
- Business.

STRATEGIC INITIATIVES

A number of strategic initiatives were undertaken to achieve the set objectives. The following show progress and achievements of the KSA:

National initiatives

There is an ongoing process within the thrusts in updating and identifying research needs and strengthening the portfolio of strategic research needs to be addressed over the short- to medium-term (2 to 5 years). During the year the following progress has been made:

- A research report on the status quo of stormwater and drainage was completed, which gives a picture of the situation in South Africa. The report is supported by a research strategy to address stormwater and drainage issues into the future.
- Similarly, a situation analysis of sewerage was also undertaken and report produced. This is supported by a WRC research strategy aimed at dealing with sewerage aspects.
- The WRC has played a key role in supporting DST's nanotechnology platform, whereby the Water Nanotechnology Strategy and Centre was established through a collaborative effort of MINTEK, WRC and DST.
- In raising the importance of sludge management, the WRC in association with DWAF is currently developing the new South African Wastewater Sludge Guidelines series. The WRC and DWAF hosted the second round of Stakeholder Workshops from July through to August 2007 to highlight the contents of the guidelines which are to be used in regulations in the near future.
- The WRC is leading the establishment of a Technical Assistance Centre to assist rural water service providers. The Centre will be expanded to also include sewage treatment. A business plan for the Centre has been developed.
- The KSA hosted a Technical Discussion Session on 'Marine Outfalls: Preparing for the Future' in Durban on 16 November 2007. More than 100 delegates, who assisted in developing a way forward in terms of R&D, attended.
- The KSA hosted an international workshop of the Sustainable Sanitation Alliance, Durban, February 2008, and was involved in the arrangements towards AFRICASAN 2008.
- The 'Water Management Excellence Conference, 15-17 August 2007, Sandton Convention Centre' was a collaborative project between DWAF, WRC and WISA aimed to assist the water sector with its current drive to ensure a turn-around in service delivery. It provided a platform for the leaders in the sector to interact with the sector as a whole. The conference programme consisted of 2 conference trains with different objectives. Conference Train 1 was called 'Water Services Quality – Ownership, pride and excellence'. The focus of this conference train was to facilitate a turn around in service quality. The sessions were custom designed for the leadership of the water service authorities, managers and service providers. The WRC hosted the wastewater management session. This conference train provided a platform for the engine room of the wastewater treatment industry, those responsible for the operation and maintenance of the wastewater treatment plants. The aim of this conference train was to promote effective operation and maintenance on an operator/process controller level.
- The WRC was represented (and presented) at the DST workshop on Technology Based Solutions for Accelerated Delivery of Water Services held in Boksburg on 23 November 2007 attended by the Hon. Deputy Minister of the Department of Science and Technology, Mr D Hanekom.
- KSA staff members continue to occupy key positions on a variety of strategic bodies and forums. Examples of these are the Steering Committees, Water Sector Leadership Group, Water information Network, JASWIC, WISA, ESETA, and Government Task Team on Acid Mine Drainage:
    - a KSA member functions as the Chair of the Minister's Water Advisory Committee
    - appointment as an advisor to the Water Demand Management Initiative of DWAF
    - appointed on the Steering Committee of the DST's new Nanotechnology Innovation Centre.
- The KSA continues to facilitate the National Water Services Benchmarking Initiative in partnership between DWAF and SALGA and the 3rd national conference was held in February 2008. Participation of local authorities during this year increased from 40 to 80.
- On appointment by DWAF, the KSA produced a guideline on the desalination of seawater along South Africa's coastline, aimed at both municipal managers and practitioners in the field.
- A KSA-completed study on creating standards for water supply chemicals is now resulting in National Standards being drawn up. The WRC has been instrumental in facilitating this process with the SABS and DWAF.
- KSA members have made a number of presentations on live radio on subjects of priority. An area which enjoyed media attention during the year was that of drinking water quality.
- The KSA hosted 8 workshops. These are reported under the KPA **Learning and innovation**, and also form the basis for stakeholder consultation and national initiatives. Note must be taken of 3 key national workshops on developing research plans for setting up of water quality laboratories, nanotechnology in water, people affected with HIV/AIDS, and strategy planning workshop on drainage and sewerage research requirements.

The element of customer/stakeholder relationship is further enhanced by WRC and its staff representations on a number of important bodies and forums. The WRC and the KSA are represented on the following forums:

- Members of the Free Basic Water Services Task Team
- Member of DWAF Water Services Regulation Team
- Member of DWAF's Asset Management Advisory Panel
- Member of the Steering Committee of the Water Dialogues
- DWAF's Project Steering Committee concerning the development of a Comprehensive Framework for Integrated Water Resource Management in the Mining Industry
- A member of the DWAF Project Steering Committee for the Development of Best Practice Guidelines for the Mining Industry
- A member of the Government Task Team convened by DME to develop an overarching strategy for mine closure
- A member of DME's Steering Committee for implementing a regional closure strategy (a

concept developed through a WRC project)

- Chamber of Mine's Steering Committee to develop *Guidelines for the Vegetation of Residue Deposits against Water and Wind Erosion*
- A member of the Coaltech 2020 Surface Environment Committee. This Committee deals with the acid mine drainage issues that are also a major focus area of the WRC research initiative. Through its involvement on this Committee the WRC remains up to date with industry research initiatives and is able to obtain industry involvement with WRC research projects
- DEAT's Steering Committee to Develop a National Strategy on Cleaner Production and Sustainable Consumption
- Management Committee of WISA's Mine Water Technical Committee
- A member of the South African Power Utility Research Advisory Board (Eskom)
- Organising Committee of WISA Biennial Conference 2008
- Board of WISA
- NTMP Programme Steering Committee
- Management and Steering Committee of the National Bench-marking Initiative
- DWAF Water Services Regulations Steering Committee
- DWAF Water Services Asset Management Steering Committee
- DEAT National Strategy for Sustainable Development
- Advisory position on the DWAF – Sanitation Technical Advisory Group and The WC/DM Advisory Group
- Appointed by the Minister to the Advisory Committee of the Groot Marico Catchment Agency
- Appointment to the Board of the Water Research Fund for Southern Africa (WARFSA).DoH invitation to meeting DWAF (RQS and supply) and WRC role of water in waterborne diarrhoea outbreaks. Invitation to DoH to more collaboration and invitation to WRC to serve on NORT.

Another key initiative is the closer collaboration between the KSA and WIN-SA. Progress and achievements to date through WIN-SA have been:

- WIN-SA took over the support of the District Water Services Managers Network, which emanated from a WRC study
- WIN-SA produced a series of booklets on lessons learned and good practices
- WIN-SA undertook an exploratory study to look at sharing of information and successes within the SADC region. There is strong support from the sector and DWAF to take this scoping exercise into application.

International initiatives

- KSA 3 is the coordinator for the South African contributions to a new European Union project – TECHHNEAU (technology enabled universal access to safe water) EU project. The project aims at rethinking current water supply options
- KSA 3 and the WRC is a member of the WHO International Group for Small Community Water Supply Management
- The KSA was invited by the UNEP-IETC to give specialist input to the development and review of the international guide on WC/WDM
- Arranged with UoJ a meeting on the cost benefits of the WHO study in Northern Province. This is to showcase the WRC study on WATSAN benefits and also the WHO methodology
- A KSA research manager was a member of the International Managerial, and Public Synergy Programme Committee for the IWA conference entitled: 'Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial and Public Synergy' held on 24-28 June 2007 in Moncton, New Brunswick, Canada. The conference was attended by 450 delegates and 44 countries were represented. The focus of the conference was to bring the technical, managerial and public perceptions in line. The KSA research manager presented an invited plenary address entitled: 'Management of wastewater and faecal sludge in Southern Africa'
- The KSA arranged a joint South Africa-European Union workshop on drinking water technology, 29 November, Cape Town
- Meeting with Bauhaus Universität Germany for possible collaboration and MoU
- A KSA member is serving on the Organising Committee of the 8th International Conference on Acid Rock Drainage to be held in Sweden in 2009
- A staff member is serving on the Organising and Advisory Committees of the 4th International Conference on Mine Closure to be held in Johannesburg in 2008
- **Global Alliance of Research Organisations of INAP.**
  The WRC is a member of the Global Alliance of Research Organisations of INAP. INAP is an international grouping of mining companies that was created to help meet the challenge of effectively dealing with the acid mine drainage problem. This network was founded in 1998 and has since become a leader in mobilising international information and experience in research, technology transfer and networking. INAP engages with a number of key regional organisations active in the field of acid mine drainage (AMD) through a Global Alliance. Currently the major initiative of INAP is to develop a Global Guide for the Management of Acid Rock Drainage. At the end of 2006 INAP invited international tenders for the development of the Global Guide. The WRC representative on the Global Alliance was elected to serve on the steering committee for the development of the Global Guide. He was also requested to chair the Global Alliance meeting held in Vancouver during November 2007. **The GWRC partnership is bringing greater collaboration in research and benefits**. To date the KSA's involvement has been rewarding and includes the following:
  - presentations were made of WRC research projects/ programmes at 2 GWRC workshops on behalf of the WRC by Prof T de Jager, UP, on Trace Organics & GWRC EDC Toolbox Kit, San Francisco, 1-18 and 21-22 May
  - review (committee member) of GWRC chapter on hazard identification in Toxic Algal Management Manual, written by Dr Bill Harding, SA
  - review of GWRC project proposal on pharmaceuticals(review committee)
  - the KSA is coordinating and managing the GWRC project of best practices in asset management.
  - presented the South African status on Energy Research and Research Needs in the Water Field, GWRC meeting, London, 2008
  - the KSA is contributing toward GWRC joint activities in endocrine disruptor and algal toxin research, coordinated by a a KSA research manager
  - further GWRC initiatives include cooperation in a membrane bioreactor research strategy plan, asset management, water and energy and in a water reuse project
- Arranged a joint South Africa-European Union workshop on drinking water technology, 29 November, Cape Town
- Invited by the UNEP-IETC to give specialist input to the development of the guide on WC/WDM
- Team member on developing WHO Guidelines of Cost Benefit Analysis of Water and Sanitation Programmes.

African leadership

The KSA played a key a role in the organising of international events:

- AFRICASAN 2008, Durban
- Hosting of the GTZ supported international initiative of the Sustainable Sanitation Alliance. The WRC held a meeting in February 2008 in Durban, aimed at fostering greater participation by African and local participants to be involved in SuSaNa
- Holding an exhibition with WIN-SA at the *Streams of Knowledge* WASH meeting, Mombassa, July 2008
- **International mine water conference:**
  A major goal of the WISA Mine Water Division is to improve the level of water management being practiced on South African mines. A KSA research manager is an active member of the Management Committee of the WISA Mine Water

Division. At its last meeting, the Committee resolved to organise an international conference jointly with the International Mine Water Association in 2008. A special focus of this conference will be to involve practitioners from the African continent. This is a timely initiative in view of the present international boom in resources development and the major mining investment being experienced by African countries. This research manager has been elected to serve on the core organising committee for the planned conference and will be chairing the Technical Organising Committee.

The IWA Sludge Management Specialist Group in association with the WHO is planning to develop an updated *Global Atlas for Wastewater Sludge Management*. A KSA research manager was tasked to manage the African sections and to assist Peter Matthews (primary author of the first edition) in this effort.

Although progress was made in building partnerships and networks, the KSA has not adequately performed in terms of strengthening its leadership in Africa. We have not managed to secure a joint research project with African counterparts. Experience tells us that this is a slow process and needs persistence.

The following stakeholder/customer relationships will be addressed during 2008/09:

- With regard to national initiatives, the KSA will continue to build on achievements of the previous year and specifically some of the initiatives include:
  - Continue to extend the *Benchmarking of Water Services* as a national programme to a further 40 municipalities
  - Continue to extend the aspects of disinfection of water supplies study towards making it a national programme
  - Support DWAF with its 2010 preparations, and in this regard the WRC Guidelines on Water Safety Plans are being applied to all 8 centres to determine their preparedness from a water perspective to meet the requirements of 2010. DWAF has earmarked funding to respond to the needs identified by the process
  - Continue to participate and provide leadership on national committees and advisory portfolios
  - Continue to strengthen and network with national partners
  - Support NSTT with research on water and HIV/AIDS
  - Closer collaboration with DME, SALGA and SAAWU, hopefully resulting in MoUs.
- With regard to African and international initiatives, the KSA will continue in line with the WRC key strategic issue of regional and international relationships, and strongly position itself globally and in Africa, with special emphasis on collaboration and sharing of water-centred knowledge. This will be achieved via cooperative agreements and partnerships that will also allow for leverage of funds and global recognition.

Public appreciation

As per plan, the KSA has completed two impact studies, one dealing with WRC's investment in the area of membrane technology and the investment in the field of sludge management. Both these studies have provided positive feedback, namely:

- In the membrane area the conclusion is that the WRC is playing an important function in fostering a strong and vibrant research culture in membrane technologies in South Africa. It is of the utmost importance that this research be continued and expanded so that creative ideas can be developed for commercial implementation. This will result in a host of positive spin-offs for the economy, society, the environment and also for the health of people and animals. The WRC has been identified as a key stakeholder in the South African membrane research and development environment and without its dedicated efforts many of the positive benefits of the research conducted would not have materialised. South Africa has a wealth of research talent and all stakeholder support in the continued development thereof is critical.
- Based on the average wastewater sludge production rate per person, if all wastewater sludge in South Africa was utilised for composting this would result in a saving of approximately R187.3 per annum for wastewater sludge managers across South Africa. Of course, this is an unlikely scenario, but it does highlight the cost-saving impact that best practice wastewater sludge management, as outlined in the *2006 Sludge Guidelines*, can have across South Africa.

GROWING THE KNOWLEDGE BASE

Capacity-building initiatives

The table on page 70 illustrates the number of post-graduate students who benefited from WRC-funded research in this KSA in 2007/08. This is in line with the set targets.

Organisation	Students from PD background	Total number of students
African Water Institute (AWI)	1	1
Cape Peninsula University of Technology	6	9
Chris Swartz Water Utilisation Engineers	16	16
Conward Consulting	3	4
Council for Geoscience	2	3
CSIR	3	6
Development Engineering Services	0	0
Digby Wells and Associates	2	4
Durban Institute of Technology	2	2
Duzi-uMngeni Conservation Trust	1	1
Emanti Management (Pty) Ltd	3	3
ERWAT	1	2
Golder Associates Africa (Pty) Ltd	7	7
Golder Associates Africa (Pty) Ltd	0	0
Hlathi Development Services	0	0
Human Sciences Research Council	2	2
Industrial and Urban Infrastructure (Pty) Ltd	0	0
Jeffares and Green Consulting Engineers	2	3
Mvula Trust	0	0
Nancy Oosthuizen Consulting cc	0	0
Nelson Mandela Metropolitan University (NMMU)	2	8
Nemai Consulting	2	2
Palmer Development Group	2	2
Partners in Development	6	6
Process Optimisation and Resource Management	0	0
Proxa (Pty) Ltd	1	1
Pulles, Howard & de Lange Inc	3	3
Rand Water	3	8
Rhodes University	3	6
Sigodi Marah Martin (Pty) Ltd	0	0
Sustainable Environmental Technologies	1	1
TBR Project	1	1
The Impact Free Water Group	4	5
Tshwane University of Technology	4	4
Umgeni Water	10	12
University of Cape Town	36	41
University of Fort Hare	7	7
University of Johannesburg	4	5
University of Johannesburg	2	2
University of KwaZulu-Natal	11	15
University of Pretoria	10	16
University of Stellenbosch	15	22
University of the North West	3	3
University of the Witwatersrand	3	3
University of Venda	7	9
University of Venda	3	3
Waterscience cc	0	0
Zitholele Consulting (Pty) Ltd	1	1
	195	**249**

At the end of the year 2007/08, 38 projects were finalised resulting in 21 Masters degrees and 5 Ph.D.s obtained through these projects. A further estimate of 28 undergraduate activities contributed to these projects. In terms of demographics 19 black males, 25 black females, 10 white males and 12 white females were involved.

Of the 30 projects finalised to date, 35 research reports have been published, 11 popular articles, 17 presentations and 20 workshops. On the academic level 6 Doctorates, 21 Masters and 20 Honours degrees have been achieved.

Knowledge-sharing and leadership

Internal learning, innovation and dissemination are paramount to the KSA meeting its goals. Following are some of the achievements to date:

- KSA related adverts were placed in the *IMESA* journal, and the South African Local Government Digest. Mvula Diary, highlighting the WRC and its contribution to the local government sector.
- The KSA hosted the following workshops:
  - half-day seminar held at HSRC – 11 April 2007 to present outcomes of the WRC Citizens Voice project. This challenging study was successful in developing models for involving communities in the regulation of water services. During progress many new aspects emerging from the study have assisted in raising the profile of this subject in the regulation strategy.
  - half-day seminar hosted at the University of Johannesburg to introduce the study of Cost Benefit Analysis of Water supply and sanitation, as well as progress and conceptual ideas emanating from the study. The study has strong linkages with WHO, 24 May 2007
  - workshops have been held on the development of guidelines for assessment and risk evaluation, analyses, sampling, and monitoring and management of EDCs in environmental source waters
  - a Workshop entitled 'Predicting Environmental Life Cycle Impacts of Mineral Wastes,' was held on 6 June 2007 at the WRC to publicise the findings of a completed **WRC project (1550: Closure Planning in the Minerals Extraction Industry: The Role of Effective Waste Characterisation and Water-Related Impact Predictions for Solid Mineral wastes)**. The overall objective of this workshop is to acquaint delegates with the methodology and results of this WRC project, and to enlist their support in taking the approach into 'the field' with site-specific case studies
  - workshop held to develop ToRs for a solicited project on sustainable tailings facilities
  - EDC risk evaluation (decision tree) workshop, UJ, 11 April
  - EDC manual development workshop, 4-5 June, Stellenbosch
- The WRC, in association with the DWAF, is currently developing the new South African Wastewater Sludge Guidelines series. A significant portion of the development focuses on review and stakeholder involvement. The WRC and DWAF hosted the second round of Stakeholder Workshops from July through to August. The workshops were held in the following centres:
  - Limpopo – Polokwane
  - Free State – Bloemfontein
  - Northern Cape – Kimberley
  - KwaZulu-Natal – Shongweni
  - Eastern Cape – East London
  - Gauteng – Pretoria
  - Western Cape – Stellenbosch
  - North West Province – Rustenburg
  - Mpumalanga – Nelspruit.
- Arranged and facilitated a workshop for the establishment of a Technical Assistance Centre to assist rural water service providers, 18 September, Development Bank of Southern Africa. The Centre will be expanded to include also sewage treatment.
- The WRC hosted a Technical Discussion Session on 'Marine Outfalls: Preparing for the Future' in Durban on 16 November 2007. More than 100 delegates attended who assisted in developing a way forward in terms of R&D.
- WRC Workshop held on the way forward and discussions with the Rietvlei Nature Reserve, Rietvlei Waterworks and the Thswane Metro (**WRC Project No 1505/1/07**).
- Together with DWAF, successfully held the 3rd National Bench-marking Workshop, Durban 26 and 27. More than70 municipalities participated in this round, an increase of 40 over the previous year. The initiative grows from strength to strength.
- Arranged a joint South Africa-European Union Workshop on drinking water technology, 29 November, Cape Town.

In addition many research projects are increasingly building technology transfer activities as a key objective in their research methodology. These take the form of popular articles, specialist workshops and web-related promotion activities. The following technology transfer actions were undertaken:

- The guest comment for the November/December issue of *Water & Sanitation Africa* focused on one of the research managers, KSA 3
- One of the KSA's research managers contributed the African overview of the article 'A global overview of the diverse world of wastewater sludge' that appeared in the December 2006 edition of WATER 21
- Interview on Radio East Coast on drinking and bottled water quality in SA, 15 June
- An article on the outcomes of storm-water and research needs identified by the WRC in WASE, March 2008.
- Arranged an open day and knowledge transfer session in Stellenbosch on 13 March 2007 to present the guidelines on seawater desalination, executed by the WRC, to the DWAF. The contents of the guidelines were explained to 70 members from the coastal municipalities and consultants and membrane systems were exhibited
- Arranged an open day on 16 March at the site of a membrane test system in the rural village of Madibogo in North West Province, to demonstrate the use of membranes in the removal of nitrates from borehole water. The knowledge was transferred to 150 people from the surrounding municipalities with similar problems, which included the local chief, councillors and the regional head of DWAF. People could taste the (better-tasting) water coming from the membrane system
- Prepared 3 Ministerial briefs, 3 policy briefs and 4 technical briefs
- Arranged an open day on 13 September near Franschhoek at the site of a novel wine and fruit effluent treatment test system based on anaerobic digestion and ozonation. The system, for which research was funded by the WRC, was demonstrated to 75 people in the industry and potential users of the technology from surrounding regions with similar problems
- A special publication on sanitation reports of the WRC in support of the Year of Sanitation and for distribution at the AFRICASAN Conference
- A special publication of drinking water
- A special publication dedicated to membrane technology
- 6 ongoing projects showcased at the bench-marking conference
- *Die Burger* (13 June 2007) 'Ernstige waarskuwing – Watersuiwering in erge toestand'
- *Daily Dispatch* (13 June 2007) 'Sewerage health warning'
- An article in the *Daily News* on dual reticulation
- Overall the KSA and the WRC have had a fair share of media publicity regarding:
  - EDCs
  - wastewater treatment plants
  - franchising
  - the degrading effect of acid mine drainage on water quality
  - radionuclides in the Wonderfonteinspruit.

The following papers have been presented by WRC staff at international and local conferences:

- Paper at the IWA Developing Countries Conference – Franchising of Water Services, Kuala Lumpur – 20 May 2007
- Presentation on Linkages between Water, Sanitation and Health – WISA Wastewater Management Conference, 12 and 13 June 2007, East London
- Presentation on Low Cost Sewerage, KZN Santag – La Mercy 13 June 2007
- National Malaria Control Steering Committee Meeting, Manhattan Hotel, 8 June (Presentation of findings of project)
- Published a paper in *Water SA* entitled 'A new strategic framework for water-related health research'. Co-authors were N Mjoli, SN Venter, R Kfir and A Moolman
- One of the KSA's research managers was a member of the international managerial, and public synergy programme committee for the IWA conference entitled: 'Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial and Public Synergy' held on 24-28 June 2007 in Moncton, New Brunswick, Canada, and

presented an invited plenary address entitled: 'Management of wastewater and faecal sludge in Southern Africa'
- Bench-marking workshop: Hartbeespoort Business Plan Framework (Inkomati CMA), WRC, presentation on Water and Health
- Presentation of EDC strategic research plan, 15 June, DG offices, DWAF
- One of the KSA's research managers presented a paper entitled: 'What makes sewage works work?' at the WISA Free State Branch Wastewater Workshop held in Bloemfontein on 16 November 2007
- Presented a paper at the World Toilet Conference, New Delhi
- Paper on franchising presented at IMESA, Durban
- Presented an overview paper on 'Decentralised water treatment technologies in Southern Africa' at the SA-European Union Drinking Water Technology workshop, Cape Town, 29 November
- Presented an overview paper on 'Water reuse in Southern Africa' at a SA-European workshop on water reuse, Cape Town, 30 November
- Presented the South African situation at a GWRC workshop on Water & Energy, 20-21 February, London
- Presented the status of South African research on acid mine drainage to the Global Alliance meeting of INAP in Vancouver, November 2007.

The KSA contributed to WRC open day sessions. Additionally, the following exhibitions were undertaken:
- Exhibition at the WASH fair, Mombassa
- Exhibition at the AFRICASAN Conference.

WIN-SA

The activities of WIN-SA are very closely associated with those of this KSA, and closer collaboration on dissemination and other WIN-SA activities will be forged. WIN-SA will therefore strive to:
- Set in motion an incremental process to improve access to and use of information and knowledge
- Ensure that users have access to appropriate information, such that the water services sector can improve its performance
- Strengthen the culture of learning and sharing amongst sector stakeholders
- Strengthen and support provincial water services resource centres and maximise returns on the existing investment in information and knowledge initiatives.

In the year under review significant progress has been achieved by WIN-SA against its set objectives. All activities under its 5 core thrust areas have been established and many milestones have been achieved:
- **Core Thrust 1 – Knowledge documentation:** 'Bringing in the Harvest Campaign' – Lessons documented and disseminated widely; the development of the WIN field notes; analysis and reviews of key sector activities and processes as timely and needed for the sector.
- **Core Thrust 2 – Access to information and knowledge:** Portal established.
- **Core Thrust 3 – Strengthening a culture of learning and sharing:** Support to sanitation lesson learning – A strategy to support Regional Sanitation Lesson Learning developed in partnership with DWAF; tools and guidelines developed to enhance knowledge-sharing practices in the sector.
- **Core Thrust 4 – Creating the capacity to assimilate and understand knowledge:** Key champions trained and capacitated; support to sector training initiatives to support accelerated water and sanitation delivery; KM tools utilised and evaluated on a continuous basis.
- **Core Thrust 5 – Building the network:** Strengthening and growing the network – WIN-SA's role as a value-adding network for the WS sector entrenched.

It is planned that in the year 2007/08, initiatives started on the 5 thrust areas will be further strengthened. These include the 'Bringing in the Harvest Campaign', lessons learning, North-South lessons sharing and strengthening the network.

IMPLEMENTATION PLAN

Research portfolio for 2007/08

The KSA's continuous activities in light of the results of the strategic needs analysis, External Review of the WRC, needs expressed by the Minister of Water Affairs and Forestry, engagement with DWAF and stakeholder engagements, with regard to its objectives and thrusts have been well supported. The External Review highlighted that the relative weight of this KSA thrusts seem to be well-balanced regarding the needs of urban-industrial-mining and rural research needs, but given the urgency to redress past inequities, the need to increase the number/weight and relevance of research projects related to sustainable rural water supply and sanitation projects. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. Thus, the primary and secondary objectives of the KSA remain unchanged.

During 2007/08 no new programmes will be initiated. However, the following consolidation and changes will be effected in **Thrust 5 – Sanitation and Hygiene Education:**

Programme 3 – Knowledge/information management and advocacy, is being closed for the reason that the framework has been developed and future work in this area will overlap with the subject areas in **Thrust 1 – Water services – Institutional and Management Issues.**

Similarly, **Programme 6 – Financial sustainability of sanitation services** is being closed, as much work has been covered and new initiatives overlap with the subject areas in **Programme 3 – Institutional and management aspects of sanitation services.**

Thus, the programmes in **Thrust 5** will be as follows:
- **Programme 1** – Advocacy, health and hygiene education
- **Programme 2** – Peri-urban sanitation research
- **Programme 3** – Institutional and management aspects of sanitation services
- **Programme 4** – Technical sustainability of sanitation services.

An indication of this is provided in Tables – these changes contribute to strengthening the portfolio of the KSA and direct the KSA towards greater relevancy and emphasis. This process is continuous and will further build and strengthen the research portfolio of the KSA.

An amount of R1 479 193 has been reserved, to allow the KSA to respond to priority research issues requiring urgent attention which have emerged from the needs expressed by the Minister of Water Affairs and Forestry and DWAF, as well as those which may emerge during the year 2007/08. One of these known initiatives is that of the further development of the BioSure™ Process. The upscaling of the technology has raised many new challenges in its operation and these need to be resolved for its wider application and the intended royalties to be realised.

The primary objective of this KSA (as presented in KSA 3 Business Plan 2006/7) is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. To achieve these objectives, strong internal processes are necessary. Strengthening internal processes and capacity will therefore continue to receive great attention.

The new portfolio of projects aims at providing solutions that support these directions in the following ways:
- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including grey water and stormwater)

- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes.

Twenty nine (29) new projects have been approved for funding, made up of 21 non-solicited and 8 solicited projects. Experience has shown that in this KSA, there is an emergence of new and critical issues requiring research. The KSA is reserving an amount of R1 880 153 to put the KSA in a position to respond to these research issues. We are already aware of a priority project in terms of finalising the operational regimes of the Biosure™ process. This step is most essential in the commercialisation process and is essential for the overall success of the technology.

The approved funding of the research portfolio for 2007/08 provides the basis for the funding of new projects for 2008/09. For 2008/09, we continue to maintain a balance between solicited and non-solicited projects. However, we are placing greater emphasis on non-solicited projects in some areas across the thrusts, as discussed below:

- **Thrust 2 – Water Supply and Treatment Technology** over the past few years had a significant growth and allocation to solicited projects. These past investments in new areas are ready to provide a spurt of new concepts and innovations. Therefore, to allow for this growth and opportunity the whole thrust is being opened to non-solicited projects. This will also afford the opportunity to identify where the greater interest amongst the research community resides in this subject area.
- Similarly, **Thrust 5 – Sanitation, Health and Hygiene Education**, has had 3 consistent years of solicited projects. The research outcomes are now mature to move into more innovative areas and opportunities need to be created. It is for these reasons that the thrust is being opened to non-solicited research.

A comprehensive revisit of all the programmes in Thrust 3 is planned for the 2007 calendar year. The scope and priorities of the future programmes in Thrust 3 will be defined through a process of interactive sessions with DWAF and other government departments, as well as users of the research products and researchers (generators of the research products). This is likely to result in the establishment of new programmes and the consolidation of some of the existing programmes. In the interim, solicited/targeted funding provision is made in programmes where current needs assessment studies are running and provision is made for the rounding-off of mature programmes. Non-solicited funding provision is being made at this stage for the programmes and strategic directions are anticipated. Ongoing strategic discussions with DWAF and stakeholders in the first half of 2007 further defined specific project scopes in these technical areas.

An overview and explanation of thrusts and programmes for KSA 3 for 2007/08 is given in **Table 1**.

TABLE 1
Overview and explanation of thrusts and programmes

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability is key to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure management, water-related competencies and capacity required for the strengthening of water institutions (water services providers, water services authorities, water boards, national departments) in providing sustainable water services.

Programme 1: Cost recovery in water services	The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this programme intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.
Programme 2: Institutional and management issues – Water services	Relationships and partnerships between service providers, both external and internal, are important prerequisites to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.
Programme 3: Innovative management arrangements – Rural water supply	The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development.
Programme 4: Regulation of water services	Regulation of water services is important for the sector to achieve improved functioning and performance of the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of the infrastructure and customers.
Programme 5: Impact of water and sanitation interventions	The programme will address aspects related to determining and quantifying the sociological, economic, technical, health, etc. impacts and benefits of 11 years of water supply and sanitation interventions in South Africa. Over the years the government has spent considerable sums of money to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits which improved water and sanitation has brought to the communities and the countries. Thus, the time is most appropriate to undertake a study of this nature.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of quality and quantity for drinking (domestic) and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. The objective of this thrust is to develop innovative technologies and processes that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

Programme 1: Drinking water treatment technology	The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.
Programme 2: Water treatment for rural communities	This programme aims to provide, through research products, adequate quantity and quality water to rural communities on a sustainable basis. Expected outcomes required to achieve sustainable water services include community involvement, cost-recovery, effective operation and maintenance, affordability and willingness to pay for water services.
Programme 3: Drinking water quality	The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.
Programme 4: Water distribution and distribution systems	The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to the end-users. The programme has the following expected outcomes: To develop reliable processes in predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs. To ensure that the quality and quantity of water is maintained in the distribution system – from the water treatment plant to the furthest end user. To develop innovative methods, tools and processes that will improve system integrity and reliability.

THRUST 3: WASTEWATER AND EFFLUENT TREATMENT AND REUSE TECHNOLOGY

Scope: The ongoing provision of sanitation services and expansion of industrial development, both of which are national developmental priorities, continually increase the need to better manage and treat the resultant wastewater and effluent flows, mitigated as far as possible by reduction-at-source measures, so that the effluent produced not only meets discharge requirements but can also be considered as a resource. Research in this thrust aims at developing technologies and systems that optimise the wastewater and waste management chain in the municipal (domestic), mining and industrial sectors, including also the institutional and infrastructural arrangements operative in these sectors. From the needs analysis carried out in 2003 and preliminary strategic research planning, the scope, definition and priorities of some of the programmes within Thrust 3 will alter from 2005/6, involving both the establishment of new programmes and the consolidation of some of the existing programmes.

Programme 1: Biological sewage treatment processes	This programme addresses the ongoing development of new or modified processes and optimisation of established aerobic and anaerobic processes for biological sewage treatment systems. Expected outcomes are greater cost-effectiveness, technical and operational control, process efficiency, performance security, affordability and application.
Programme2: Sludge characterisation, treatment, utilisation and disposal	This programme deals with the systematic characterisation, quantification and categorisation of sludge from domestic and industrial sources in the RSA. The overall expected outcome is a greater capability for the development of technically-secure, cost-effective, environmentally acceptable and sustainable treatment process technologies, utilisation strategies and disposal practices.
Programme 3: Treatment and recovery of organics from agro-industrial processing	This programme addresses the development and piloting through to full-scale implementation of treatment and/or conversion technologies for problematic organic effluents from agro-industry processing including forestry (pulp and paper) and livestock products, particularly in respect of organic components which are too concentrated, refractory, inhibitory or even toxic for the biological treatment processes normally available at municipal sewage works.
Programme 4: Treatment and recovery of inorganics (including sulphate, metals) in industrial and mining effluents	This programme aims to develop a range of processes for effective treatment and disposal of industrial and mining effluents containing components such as heavy metals and inorganic salts, which have deleterious bio-inhibitory or bio-toxic effects on the performance of sewage works, the fitness of treated wastewaters for reuse, the sludge quality produced and the aquatic environment in general. Expected outcomes include the potential recovery of materials and water for beneficial reuse and fundamental scientific/engineering support for process development.
Programme 5: Training in wastewater treatment plant operation	This programme aims at researching, developing and delivery of appropriate tools, course material, management systems and providing training for wastewater treatment plant operators. The purpose is to strengthen and enhance the skills base (competency and expertise) necessary for effective control and management of the diverse needs of the water industry in the RSA.

Programme 6: Biotechnological co-treatment of industrial/mining effluents with sewage wastewaters	The programme objective is to exploit and further develop beneficial applications of biotechnological processes for co-treating saline and sewage wastewaters in the sustainable and integrated management of various water-related communities, industrial, agricultural and environmental needs.
Programme 7: Sewerage reticulation	This programme aims at addressing technical design, operational, maintenance, refurbishment and management aspects of sewerage reticulation systems, which have been identified as a concern in the sustainable provision and protection of asset infrastructure in the extended delivery of sanitation services as a national priority.
Programme 8: Storm water management	This programme addresses strategic and technical aspects of managing stormwater flows and impacts in urban, peri-urban and rural contexts, with their different implications for water resources, community health, environmental impacts, etc.
Programme 9: Energy from waste	This programme is established to investigate sustainable methods and technologies for generating energy from domestic and industrial waste sources.

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. This thrust aims to provide appropriate, innovative and integrated solutions for water use and waste management in the industrial and mining sectors.

Programme 1: Quantification of water use and waste production	In order to prioritise those facets of industrial and mine-water management that need most urgent attention, it is important to quantify the water used and waste produced by different sectors. The NATSURV investigation conducted by the WRC provides the bench-mark for water use and waste that are produced by the major South African industries. While the WRC has reported on water use by coal mines and COMRO on water use by gold mines, no overall assessment of the effect of mining or industrial waste on water quality is available. The available information thus needs to be updated and refined. Furthermore, new information needs to be gathered for those sectors that may present important emerging issues.
Programme 2: Regulatory mechanisms to improve industrial and mine-water management	The regulatory authorities are responsible for managing the impact of industrial and mining waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used almost exclusively to manage water quality. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new approaches are believed to be more cost effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the regulatory mechanisms that are used to control and reduce the negative environmental effects associated with industrial and mining waste.
Programme 3: Minimising the impact of waste on the water environment	South Africa has a large legacy of mining and industrial waste products that impact negatively on the water environment. In spite of efforts to the contrary, the quantity and range of waste products are expected to increase for the foreseeable future. It is thus necessary to develop cost-effective techniques and approaches to minimise or reduce the impact that historical and new waste products have on the water environment. Approaches such as pollution prevention, rehabilitation, waste beneficiation and reuse, are investigated to assess their application potential and suitability to reduce and minimise the negative impact of industrial and mining waste on water quality.
Programme 4: Minimising waste production	A direct link exists between the quantity of waste produced and its impact on the water environment. The type of waste that is produced may, however, often be of even greater importance than quantity. In order to reduce the negative impact of waste production, it is important to reduce both the quantity and toxicity of waste. The international trend towards waste management is therefore to minimise the production of waste by adopting cleaner production processes. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. This programme investigates and promotes the implementation of approaches that minimise waste production.
Programme 5: Improved ability to predict and quantify effects	The environmental consequences of waste products are almost always long-term in nature, with impacts that may potentially last for hundreds of years. These long-lasting effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impact of their operations and to indicate how these will be remedied. This programme is primarily aimed at establishing and improving pollution prediction capabilities appropriate to the South African situation.

THRUST 5: SANITATION, HEALTH AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery (O&M, sustainability etc.) beyond 2010. The focus is on low-cost and affordable sanitation technologies.

Programme 1: Advocacy, health and hygiene education	The main objective of this programme is to support the integration of health and hygiene into the delivery of water and sanitation in order to ensure that these services lead to maximum health benefits for the beneficiary communities.
Programme 2: Peri-urban sanitation research	The aim of this programme is to provide research support to sanitation in informal and developing urban areas. Until recently the focus of sanitation has been on rural areas, but the situation in urban areas is much more critical and volatile in terms of public health. Urban sanitation differs from rural sanitation issues related to institutional arrangements, community dynamics and management of interventions. Due to the high densities, technical choices are more complex where an affordable and sustainable service is to be provided. Outcomes from this programme will support local authorities in implementing sustainable solutions, which cater for both the user and the institutions' needs.
Programme 3: Institutional and management aspects of sanitation service delivery	The main objective of this research programme is to develop institutional models, tools and guidelines that will support the improvement of delivery (O&M, sustainability, etc.) of sanitation services.
Programme 4: Technical sustainability of sanitation services	To develop tools, procedures and guidelines that will guide those responsible for implementing projects in their selection of appropriate sanitation technologies that are socially, environmentally and financially sustainable.

RESEARCH PROJECTS FOR 2007/08

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Interactive mechanisms for WRC research to support municipal water services knowledge management
Sigodi Marah Martin
No 1611

Various WSIPs at first tier governance level such as DWAF, the Development Bank of Southern Africa (DBSA), the WRC, the Council for Scientific and Industrial Research (CSIR), the Human Sciences Research Council (HSRC), Statistics South Africa (StatsSA) and the South African Data Archive (SADA), have an abundance of information pertaining to the Water Services Authorities and Local government at their disposal. The objectives of this study were to carry out a survey of this information exchange between the WSIPs and WSAs/LG institutions in South Africa and to come up with findings which are fundamentally aimed at improving the delivery of water services in South Africa.
The study found that the written and electronic communication channels are the most commonly used channels in the water services sector of South Africa. Contrary, to perception in the sector, it was found that 85% of local authorities in South Africa are connected electronically to LGNet. Since electronic communication channels are the preferred channels for information exchange between the WSIPs and WSAs/LG institutions in South Africa, a generally accepted and effective one-stop-shop on the web will therefore contribute to more efficient and effective information exchange in the water services sector of South Africa. When electronic communication channels are used, the recipients at especially the WSAs/LG institutions in South Africa can engage in real 'knowledge management' by retrieving, accessing and archiving information as and when needed. It was concluded that the WSIPs in South Africa probably underestimate the level of access WSAs/LG bodies have to electronic communication channels already and thus, this channel is underused for information dissemination. Finally, the research has identified that currently there is a definite lack of human and financial resources for information exchange at both the WSIP and the WSA/LG institutions in South Africa. A major finding of this study therefore is that the WSA/LG institutions generally do have the necessary tools and capacity available to decode and understand messages which are sent to them electronically.

Cost: R622 000
Term: 2005-2007

Programme 3: Innovative management arrangements – Rural water supply

The state of community consultation in the provision of water services
Sigodi Marah Martin
No 1616

Community consultation in the provision of water services is both a legislative obligation and a critical success factor. No single comprehensive study has been done which provides a barometer of the general public's knowledge and understanding of the water services messages as communicated, and their involvement in, and preferences for, consultative processes. For the purpose of this study, the term 'community consultation' was broadly defined to include all types of communication aimed at the general public, ranging from information dissemination to community participation. The study limited itself to water services messages and it focuses on two major communication campaigns of DWAF that have dealt specifically with Water Services, Free Basic Water and Water and Sanitation Hygiene (WASH).

The 5 key water services knowledge areas were identified (Free Basic Water; Basic Water as a Constitutional Right; Responsibilities; Health and Hygiene; and Institutional Roles) and the knowledge and understanding of South Africans were established via a quantitative survey. The results were presented using a 'barometer' instrument. The results showed that 'Responsibilities' scored higher than 'Rights', i.e. people have better knowledge of their responsibilities than their rights. South Africans

seem to be at least aware of their responsibility to pay for water in excess of 6000 litres/month and to report broken infrastructure that directly affects them. This is also the case with answers on Health and Hygiene received from respondents. South African adults scored the lowest in the areas Free Basic Water and Constitutional Rights, because 59% said that they have never heard of Free Basic Water and 45% said they have never heard of the Constitution. The study also highlighted that more focused interpersonal interventions are necessary to bring rural consumers on par with urban consumers. These would include meetings, community development workers/municipal development officials, community networks, community media and tribal messengers. South Africans cannot exercise their constitutional rights if they have never heard of the Constitution.

Cost: R700 000
Term: 2005-2007

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Polyelectrolyte determination in drinking water
Umgeni Water
No 1528

The quantity of residual polyelectrolyte which includes poly diallyldimethyl ammonium chloride (polydadmac) and epichlorohydrin-dimethylamine (epi-dma) in drinking water treatment is a growing cause for concern due to the adverse health effects it poses for potable water consumers. Historically, inorganic coagulants such as aluminium sulphate and ferric chloride have been used as coagulants/flocculants in the treatment of drinking water. The residual amounts of these chemicals were easy to detect and control using readily available standard methods. The increasing use of polyelectrolytes has created a problem for the potable water industry as there are no readily available methods for the determination of residual polyelectrolyte concentration which is especially needed when over-dosing or spillage occurs. It was, therefore, required to develop, adapt and evaluate suitable methods for the determination of residual polyelectrolyte in final potable water distributed to the consumer. The following 4 methods were evaluated and further developed in the study: a potassium polyvinylsulphate (KPVS) method, a Ponceau S dye method, a tannic acid method and a high-pressure liquid chromatography (HPLC) method.

From the methods investigated, the former 2 were most successful in quantifying the amount of residual polyelectrolyte. These methods showed good precision with linear calibration curves. Detection limits of 1 mg/l of polymer concentration could be achieved. The colloidal titration method proved to be a simple and cost effective method with minimal interference compared to the Ponceau S dye method. These methods were simple enough to allow for continuous monitoring in a potable production process. Thus, the key output of this study was the development of 2 simple and practical analysis methods for residual polymer detection in water, thereby ensuring the safety of the final water reaching the consumers.

Cost: R300 000
Term: 2004-2006

Programme 2: Water treatment for rural communities

The evaluation and selection of small water treatment systems for potable water supply
Chris Swartz Water Utilisation Engineers
No 1443

Small water treatment plants are defined as water treatment systems that have to be installed in areas which are not adequately serviced and do not normally fall within the confines of urban areas. They are therefore mostly used in rural and peri-urban areas and include chlorination plants for water supplies from boreholes and springs, small treatment systems for rural communities, treatment plants of small municipalities and treatment plants for establishments such as rural hospitals, schools, clinics, forestry stations, etc. Most of these applications require small plants of less than 2.5 ML/d (although plants of up to 25 ML/d may sometimes also fall into this category). The decision maker selecting one of these small water treatment plants has a great number of local and international system designs to choose from. Especially in the case of novel and emerging systems, very little may be known of these systems in terms of cost, efficiency and the applicability to the intended application. This guidebook is therefore seen as complementing existing guidelines in providing assistance in the selection and operation of specific small water treatment systems being marketed for the treatment of potable water for small communities.

A number of local and international studies have shown that the selection of the correct water treatment system is but a first step in ensuring a sustainable supply of potable water to small communities. Following of the correct operational and maintenance procedures is of even greater importance for ensuring sustainability of water supply. Although most suppliers of small water treatment systems provide their clients with some operational and maintenance guidelines, these may not be exhaustive, or certain important generic aspects may not be covered. Information on operation and maintenance aspects will be of significant value to the owners and operators of such small water treatment systems. The guidebook aims to provide guidelines for the identification and optimal selection of available and emerging new water treatment systems, which are currently being marketed for the supply of potable water to small communities in South Africa.

Cost: R1 200 000
Term: 2003-2006

Enabling water fluoridation in small drinking water treatment plants
Umgeni Water
No 1530

Regulations for the fluoridation of South African potable water supplies to an optimum concentration of (and not more than) 0.7 mg/l in order to limit the development of dental cavities were published in the Government Gazette of 8 September 2000. Water Services Providers (WSPs) had to register with the Department of Health (DoH) by 8 September 2001 for fluoridation of their water supplies to consumers – or apply for exemption. However, because of the larger safety risk foreseen for both plant operators and water users in smaller and rural water treatment plants, such plants supplying water to less than 60 000 people, currently receive, on application, temporary exemption from the Director-General: Health. This unfortunately excludes a large part of the population from receiving the benefits of fluoridation. By far the majority of water treatment plants fall within the category of supplying less than 60 000 people with potable water. In addition, most of the operators on these smaller plants are not at a skills level required by the regulations for the safe operation of a fluoride dosing facility. A need therefore existed to enable these smaller plants to administer fluoride safely through the correct choice and operation of instrumentation and equipment, as well as by innovative ways in which to make a plant fail-safe in terms of both technology and human shortcomings. The project aimed to enable fluoridation to be done safely on small water treatment plants by means of the evaluation, selection and implementation of safe handling and dosing equipment and monitoring instrumentation.

Potentially suitable handling and dosing equipment and monitoring instrumentation were evaluated at an Umgeni Water treatment plant and the following products emanated from the study and evaluation:

- A full report was produced on the various fluoridation handling, dosing and monitoring equipment evaluated, including cost implications to the water treatment plant.
- A comprehensive guideline document was compiled, outlining suitable fluoridation techniques, equipment available, correct installation and use of the equipment and

general safety measures that (especially) small plant personnel need to adhere to. In the light of the fact that fluoridation will go ahead in the near future, this guideline is a very timely document, which will assist especially the small water treatment facilities – but also larger plants – in ensuring that their fluoridation requirements are met in an efficient and safe way.

Cost: R1 200 000
Term: 2004-2007

Improving the efficiency of disinfection in small drinking water treatment plants
University of Fort Hare
No 1531

The efficacy of drinking water treatment by small water treatment plants – and particularly the disinfection aspects thereof, is fraught with several technical and management problems. This is corroborated by the extensive documentation on the supply of water of poor microbiological quality which is unsafe for human consumption in different provinces of South Africa. In order to unravel the intricacies around the operational and management parameters impinging upon the disinfection efficiency of small water treatment plants and to ensure sustainability of potable water supply to rural communities, this study was executed, involving 181 small water treatment plants across 7 provinces of South Africa. The goal was to determine the nature and full extent of the disinfection problems experienced and to provide practical and user-friendly guidelines for intervention.

From extensive surveys at these plants and their disinfection systems, it was established that equipment, maintenance, operator education, operator training, operator working conditions and management-operator interaction were normally inadequate. These aspects were quantified and graphically portrayed on the report. A detailed and user-friendly guide document was further drawn up to assist in improving disinfection of final water at small water treatment plants and distribution systems. It includes practical steps and also installation and operating costs for the different disinfection systems and chemicals. This guide document is intended for use at operational and management levels by plant managers, supervisors, plant operators and plant owners, consultants and Municipal Water Local Authorities. The report and guide document will fulfil a long-standing need for more complete information on (both technical and social) aspects regarding improved final water quality produced from small water treatment systems in South Africa.

Cost: R1 000 000
Term: 2004-2006

Programme 3: Drinking water quality

Occurrence and fate of EDCs in drinking water
CSIR
No 1532

Natural hormones, including estrogens, can be released into the environment via sewage effluent and from sources such as animal feedlots. Studies have shown that a number of EDCs (e.g. nonyl phenol, chlorinated pesticides, polychlorinated biphenyls (PCBs)] are present in South African surface water and effluent discharges. The presence of EDCs in drinking water sources is a matter of great concern and poses the question of how effectively these chemicals are removed by conventional water treatment methods. Due to the wide structural diversity of these chemicals, more than one process may be required for their removal. This pilot study was carried out to investigate the occurrence of oestrogen mimicking substances and estrogenic activity in the source and treated drinking water, in drinking water treatment plants using biological/biochemical techniques as well as its removal by different treatment processes and to make recommendations on the most appropriate combination of tests for the detection of estrogenic activity in drinking water.

A battery of *in vivo and in vitro* biological/biochemical techniques established by different South African and overseas laboratories were applied according to published protocols. Three drinking water treatment plants were selected for the study. Source water and water from selected treatment processes (e.g. flocculation, sand filtration, and chlorination) were tested over a 1 year period. The bioassays clearly showed estrogenic activity in source and treated drinking water. Chemical analysis also indicated that triazines and nonyl phenol were occasionally detected in water samples. The estrogenic compounds 17α- and β-estradiol, estrone, 17α-ethinylestradiol and estriol in all the water samples were below the detection limit of 1.0 ng/ℓ. The results obtained with the YES and ER-CALUX assay showed a reduction in removal of oestrogenicity by the water treatment processes. The most significant reductions were observed in the final waters, after chlorination. In general, both assays indicated some increase in estrogenic activity after the addition of flocculants. A reduction of triazines and p-nonyl phenol concentration in final waters was also noticed during 50 to 75% of the sampling occasions. Factors such as heavy rain, high algal loads and changes in flocculant did not appear to have impacted on the water quality. What appeared to be an important factor in the efficiency of treatment plants to reduce and remove oestrogenicity was the source water quality. The YES and ER-CALUX and PRTH assays proved to be the most suitable for the detection of oestrogenicity in drinking waters. The *in vivo* tests did not perform well in the study. *In vivo* tests are time consuming and there are many variables that can impose errors in the assays. These tests are, therefore, not recommended for drinking water testing. In order to establish the cause of these effects, extensive chemical monitoring programmes are recommended. Risk assessment will also be required to provide answers on the risk involved in drinking water exhibiting oestrogenicity.

Cost: R830 000
Term: 2004-2006

Determination of the specific origin of contaminating bacteria in drinking water of rural households by elucidating the contamination pathway using amplified fragment length polymorphism (AFLP)
CSIR
No 1602

To improve access to better quality water in rural areas in South Africa much effort has gone into providing people with protected boreholes and standpipes at some distance from their homes and it is mostly stored in-house in containers. It has, however, been shown that the microbial quality of the water stored in-house, determined by indicator organisms such as faecal coliforms, deteriorates considerably between point-of-collection and point-of-use. The study was aimed at gaining information about the most likely point of introduction or origin of enterococci bacteria into drinking water stored in rural households.

Enterococcus species were specifically selected for this study because of its ability to survive for longer periods than E. coli in the environment. The AFLP method was applied to determine the genetic relatedness of enterococci isolates isolated from the source waters, water from storage containers, drinking cups, hand-swab samples, some swab samples taken from the outside surface of the drinking cups, porridge, rice and dung from domestic animals. Analysis of the AFLP results obtained for the enterococci isolates obtained for the 30 households that were dependent on an untreated river water source and 5 households dependent on a less contaminated drinking water source showed a very wide variety of genetic patterns. The genetic relatedness of the enterococci isolated during this study could not directly been related to a specific genetic pattern in the domestic samples of the households, a specific place for the introduction of the contaminants or their origin. The genetic patterns, however, highlighted specific links that could be associated with handling of food and water in individual households. It would be possible to successfully apply this method for a specific, local purpose. The high genetic diversity confirmed that multiple contamination sources are involved in contamination of drinking water. The identical genetic patterns observed for a considerable number of AFLP

types, associated with a specific sample type, for example the river water or the storage container waters, indicated clusters of enterococci which has undergone subtle changes in the genetic material. These changes take place once the bacteria enter and have to adapt to a new environments where they almost become a 'different' organism in order to survive. A clear pattern, showing genetic links between enterococci isolated from individual households, rather than between neighbouring households, indicated that contaminants are specific to households and their individual household practices. The findings of this study indicated that the AFLP fingerprinting method may be better suited for understanding the occurrence and spread of selected contaminating organisms in a specific localised setting.

Cost: R371 320
Term: 2005-2007

On-line real-time enzymatic biosensor system for the rapid detection of faecal contamination of water intended for drinking purposes
Rhodes University
No 1603

Water intended for drinking purposes is under constant threat from a wide variety of pollutants in the environment. Inadequate sanitation frequently results in the channelling of untreated sewage and faecal material into water sources. This increases the potential of outbreaks of water borne diseases. Current tests to detect pathogens (or rather indicator micro-organisms, i.e. total and faecal coliforms, *E. coli*, etc.) are in place to detect and quantify the presence of faecal contamination, but these require laborious and time-consuming procedures. WRC *Report No 1446/1/07* describes the establishment of a suitable bioprobe and biosensor system for the rapid enzymatic detection and enumeration of indicators of faecal contamination in water. One of the key outputs of the study is the design of a suitable bioprobe strip for the rapid detection of faecal contamination.

This project was aimed at extending the proof of concept into a working product fit for use under a wide range of environmental conditions – such as the feasible use of this biosensor at varying ambient temperatures and in the presence of potentially interfering substances of chemical or biological origin, such as nitrates, cadmium, sodium chloride (sea water), carbonates, phosphates and other similar ions. The electrochemical detection of *Escherichia coli* β-D-glucuronidase activity as a means of monitoring water pollution by faecal material was investigated using separate *Moraxella*- and *Pseudomonas putida*-modified glassy carbon electrodes. A voltammetric sensor prepared by the immobilisation of phthalocyanine metal complexes onto a glassy carbon electrode was also developed for the detection of β-D-galactosidase of faecal origin in water. Electro-oxidation detection of chlorophenol red (CPR), a breakdown product of the chromogenic substrate chlorophenol red β-D-galactopyranoside (CPRG), was used as a measure of β-D-galactosidase activity. The *Moraxella*-modified biosensor detected activity of β-D-glucuronidase from viable but non-culturable *E. coli* cells and can therefore serve as a presence or absence device for rapid water quality monitoring. A strong correlation between the copper phthalocyanine metal complex modified glassy carbon electrode sensor sensitivity and total coliform colony forming units (CFU) was observed. This sensor thus provided a sensitive and robust method for the detection of coliform contamination of water. In this study, the use of environmental samples for in situ GUD/GAL assays assisted in applying laboratory-developed protocols to the field. The study also provides cost-effective solutions for biosensor implementation in field and culminated in a biosensor product, covered by an RSA patent.

Cost: R700 000
Term: 2005-2007

Programme 4: Water distribution and distribution systems

The status and use of drinking water conservation and savings devices in the domestic and commercial environments in South Africa
Partners in Development
No 1606

This study included four different surveys in order to gauge the status and use of water-efficient devices in South Africa. Firstly, commercial and institutional settings such as hotels and hostels were investigated; secondly, the suppliers of plumbing fittings were studied; thirdly, the architectural profession was surveyed; and finally the knowledge and attitude of 1 428 home owners in 10 towns and cities in South Africa were tested. The findings indicate that in commercial and institutional settings, there is clear evidence that water efficient devices are becoming more common. The plumbing industry demonstrates an increasing market share of water efficient devices and this is apparent on the showroom floors of the major plumbing suppliers. This is almost in spite of the suppliers, who as a rule do not push water efficiency (as one said, it is not their job to preach to their customers, who buy mainly on functionality, style and cost). Of the 1 428 homeowners surveyed, 29% indicated that they had at least one water efficient device in the home. Typically only about 20% of the respondents in the average town believed they might possibly use too much water, but significantly more, 40 to 50%, have considered reducing their water consumption.
Cost: R700 000
Term: 2005-2007

THRUST 3: WASTEWATER AND EFFLUENT TREATMENT AND REUSE TECHNOLOGY

Programme 2: Sludge characterisation, treatment, utilisation and disposal

Survey and methodology for analysing organic pollutants in South African sewage sludges
School of Chemical and Physical Sciences, University of KwaZulu-Natal
No 1339

The *Guidelines for the Utilisation and Disposal of Wastewater Sludge* promote the application of sewage sludge to land as a beneficial and sustainable option to utilise sewage sludge. Although it is recognised that organic pollutants can also limit its utilisation potential, practically no information exist on the organic pollutants present in SA sewage sludges. This project aimed to conduct a survey of organic pollutants in SA sludges, establish methods to sample, preserve, extract and analyse organic pollutants in sludge, as well as give guidance concerning permissible levels for organic pollutants. A literature survey indicated that most organic pollutants are not taken up by plants. The risk for human exposure resides with the spreading of sludge onto crops that are eaten raw or semi-cooked or by consuming animal products where animals ingest soil and sludge directly when grazing on sludge-treated land. A total of 109 samples from 78 sewage works were extracted, using Soxhlet extraction for solids and liquid-liquid extraction for liquid samples. A total of 712 organic compounds were identified in South African sewage sludge. The results from the study showed that there was a low level of occurrence of organochlorine pesticides (that are listed for regulation in the *1997 Guidelines*). This suggests that there is no need to continue regulating this group of organic pollutants. The 3 compounds or groups that require regular monitoring based on their occurrence are p-cresol, nonylphenols and PAHs (group of 9 as in the EU 2000 draft). Since liquid sludge contains high values for phenols when compared to solid sludge, it is recommended that the effluent from wastewater plants be analysed for nonylphenols. PCBs should be quantified and regularly checked, especially in Gauteng where it was detected. Other listed compounds (namely PCDD/F, DEHP, LAS and AOX) should be quantified in only a few areas to gauge their level of occurrence. There is no need to do regular checks on LAS and AOX compounds because, based on EU limits, their toxicity levels are not so critical. The study recommended the need to carry out a 5-yearly monitoring process.

This study provided much-needed information on the quality of South African sewage sludge with respect to organic pollutants. The project assessed the

current South African Guidelines by comparing their findings with the limits set by the *Guidelines* and international limits. This information supported decision making at national level and assisted with Edition 2 of the sludge Guidelines.

Cost: R580 000
Term: 2002-2005

Adopting internationally acceptable methods and building capacity to measure helminth ova in wastewater and sludge samples
Zitholele Consulting (Pty) Ltd
No 1662

The objective of this study was to adopt and document an internationally acceptable method to measure helminth ova in wastewater, sludge and soil samples, and subsequently build capacity in South African Water and Wastewater Laboratories on the method. The motivation for the project is that in South Africa, currently no standard method exists for measuring Helminth ova in wastewater, wastewater sludge or soil samples. The presence of *Ascaris lumbricoides* eggs is frequently the only 'standard' that is used. This project thus sought to evaluate the strengths and cost-effectiveness of 2 methods:

- An adapted EPA method as recommended by Professor B Jiménez's Research Group, at the Institute of Engineering, National Autonomous University of Mexico
- The ammonium bicarbonate/zinc sulphate – AmBic/ZnSO4 method developed and reported by the Pollution Research Group in South Africa.

Both these methods were evaluated for suitability, efficiency and cost-effectiveness. The adapted EPA method, the Visser® Filter method (a commonly used method) and the PRG's AmBic/ZnSO4 method, for the extraction of helminth ova from human waste materials, were tested in collaboration between the Mexican group, the UKZN-PR Group and ERWAT. This work resulted in a simpler, cost-effective and accurate method for the South African context. The method, which is based on a combination of washes, filtrations and flotations, has been adapted into three 'separate' methods to suit the main groups of waste products, viz. wastewater or effluent, wet sludge, and dry or composted sludge and UD-waste. As part of this study, seven laboratories were trained on the method at two training sessions that were held during February 2007. This report documents the procedure and approach followed, the final methods, the training sessions and feedback received.

Cost: R273 000
Term: 2006-2007

Programme 3: Treatment and recovery of organics from agro-industrial processing

Assessment of a baffled (compartmentalised) anaerobic digester for the treatment of high-strength and toxic organic industrial effluents
Pollution Research Group, University of KwaZulu-Natal
No 853

Initial studies showed that high-strength and toxic effluents were amenable to a certain extent to anaerobic digestion. This study looked at anaerobic baffle reactors as a suitable technology design for treating high-strength and toxic industrial effluents due to its ability to function at shorter retention times while still retaining the slow-growing bacteria which are required for the final steps of anaerobic digestion. Testing was done on several food and textile dyes as well as industrial effluents. The feed substrate and industrial effluent was first tested using standard biodegradability assays. Laboratory-scale reactors fed with the food dye, tartrazine, was able to achieve 90% colour removal and colour removal increased with time suggesting that the anaerobic biomass was able to acclimatise to the dye. It was reported that colour removal occurred in the first compartment of the reactor. The second set of studies which, investigated the treatment of textile trade effluent, was able to achieve 70% organic carbon and 90% colour removal respectively. It was reported that decolouration was due to adsorption onto biomass. A third study looked at an effluent containing the CI reactive dye 141. The ABR was able to achieve >90% COD removal and 86% colour removal. The study also showed that shock loading the reactor lead to temporary inhibition and the reactor recovered within 5 HRTs. The ABR was also compared to a conventional completely stirred anaerobic digester. Results showed that the ABR was more stable and could withstand a greater industrial shock load. The study concluded that the ABR was able to successfully treat highly coloured wastewater and that the design of the ABR facilitates efficient treatment of concentrated textile effluents by protecting the sensitive methanogenic bacteria and preventing washout of the sensitive micro-organisms.

The study also tested the co-digestion of domestic and industrial effluent on a pilot-scale rig and found that the effluent was not suitable for discharge to waste courses without a final polishing step. The major disadvantage of the system is that it is unable to significantly remove pathogens from the effluent. Thus, for South Africa, the ABR could be implemented for on-site pretreatment of agro-industrial wastes, with high COD content and xenobiotic compounds.

Cost: R1 218 000
Term: 1998-2001

To investigate and commercialise production of a cocktail of hydrolytic enzymes from anaerobic sulphidogenic bioreactor fed with sulphate reducing bacteria and municipal sewage sludge for the treatment of biological and industrial wastewater
Rhodes University
No 1541

WRC Project No 1170 identified the involvement of a plethora of hydrolase enzymes (glucosidases, proteases, lipases) in a biosulphidogenic reactor and found that these enzymes could be used, *in situ*, to bioremediate effluents from acid mine drainage, tanneries and abattoirs. In the case of the hydrolases the crude enzyme mixture is self-sustaining and their respective reactions can occur without any necessary cofactors. With the textile dye effluent, however, it was necessary to reduce the azo –N=N- bond through the action of the hydrogenase enzyme. The researchers examined the use of SRB cells as a whole (or rather the SRB cells from within the BioSURE Process® sludge itself). This resulted in a complete decolourisation and degradation of the azo dyes from within the textile dye industrial effluent. However, when 'pure' SRB (from a culture on lactate medium) was used, there was very little breakdown of the single aromatic compounds, as indicated by the fact that the absorbance at 280 nm remained fairly significant. This was evident with both authentic dyes and industrial samples. With SRB from the BioSURE Process® sludge there was complete degradation and a subsequent removal of the aromatic compounds absorbing at 280 nm. It is hypothesised to be the result of an anaerobic degradation of the dyes into their constituent aromatic amines followed by an aerobic degradation into CO_2, H_2O and NH_3. With the 'pure' SRB system this doesn't happen. It is estimated that for an enzyme activity of 2 200 µmol/min per ml of sulphidogenic sludge, 1 kg of sludge (1 000 ml) would decolour 2.2 mols of azo dye [770 grams Orange II] in one minute. It is recommended that in order to completely decolour and degrade the azo dyes from an industrial waste effluent, a dried powdered extract of SRB-BioSURE Process® sludge from a biosulphidogenic reactor, including all of the necessary enzymes and cofactors *in situ* be used.

Cost: R216 000
Term: 2004-2005

Integrated research to identify indigenous flora and microflora for use in constructed wetlands for agro-industry effluent treatment, especially winery wastewater
University of Cape Town
No 1544

The South African wine industry disposes approximately a billion litres of wastewater annually, as a direct result of winemaking activities and a large percentage of this wastewater contributes to the environmental degradation in the drainage basins of the main water catchments of the Western Cape Province – namely the Breede River, the Olifants River, and the Berg River. The high seasonal COD wastewaters with a high level of sodium and potassium ions contribute significantly to the eutrophication and deoxygenation of rivers and groundwaters in these drainage basins. The main objectives of this study were to demonstrate the feasibility of modelling a constructed wetland, based on information correlating to microbial and enzyme activities with organic pollutant removal and to identify soil, water and plant root microbes present in wine wastewater wetlands using phylogenetic techniques.

Findings from chemical characterisation and modelling of wetland performance confirm that the biodegradation of winery waste taking place in the wetland can be effectively characterised. In the initial characterisation of winery wastewater, ethanol is the major constituent of winery effluent and contributes approximately 86 to 91% of the COD; ethanol levels were shown to rise to above 4mL/L at certain times. Acetic acid is the second organic component that contributes significantly to the COD of winery effluent. Based on botanical survey results, it is recommended that the constructed wetland be sub-divided into regions. The length of the wetland should be divided into four equal regions. The first region should be planted with a combination of *Carex* (common sedge) and *Zantedeschia aethiopica* (Arum Lily). The second region should be planted with *Zantedeschia aethiopica* (Arum Lily) and *Typha capensis* (Bullrush). Region 3 should be planted with Arum lilies and Region 4 should be planted with *Pesicaria decipiens*. This would provide for a greater degree of plant biodiversity, which would in turn provide increased bio-remediation. These plants are known to be resistant to winery effluent and are indigenous. Microbiological and biochemical analyses demonstrated that the microbial community present in the wetlands, and its seasonal variation, could be effectively characterised using phylogenetic techniques. Constructed wetlands have been demonstrated to be both feasible and practical method of treating winery effluent. A conservative semi-empirical model has been developed that predicts the effluent treatment efficiency of the constructed wetlands. The correct plants have been identified for use in constructed wetlands for use in the Western Cape Province and include primarily sedge species and Arum lilies. This model, in conjunction with the botanical data, can be used for the design of new constructed wetlands for the wine industry.

Cost: R500 000
Term: 2004-2006

Programme 4: Treatment and recovery of inorganics in industrial and mining effluents

Investigation into sulphur chemistry with specific application to biological sulphate removal processes
Department of Civil Engineering, University of Cape Town
No 1079

The chemistry of acid mine drainage (AMD) waters is governed largely by pH-redox equilibrium chemistry of the sulphur system, the metal ion systems present, as well as the influence of the carbonate system in the aqueous, solid and gas phases. The principal aims of this project were to investigate and model:

- The sulphide chemistry in both the aqueous and gaseous phases
- The recovery of elemental sulphur through chemical oxidation of sulphide
- The precipitation and recovery of metals. Consideration was given to the feasibility of developing a unit process to effect elemental sulphur recovery using physico-chemical methods.

Two approaches to removal of sulphides are considered accepting that sulphate is reduced first to sulphide in the Rhodes BioSure® System. First, passive diffusion of gaseous sulphide across a permeable silicone membrane was investigated. The tentative experiments conducted indicate that removal of sulphide via H_2S moving across a silicone membrane allows S^0 removal at about a rate of 140 g S^0 / m² membrane per day for a membrane thickness of 0.7 mm. This rate is too low to have practical viability for treatment of large volumes of wastewater such as AMD effluents. In addition, membrane fouling due to biological activity or mineral precipitation could further reduce this rate and the feasibility of this approach. Second, stripping of sulphide species using CO_2 as a Spurger and carrier gas was investigated. Aspects investigated included measurement of hydrogen sulphide (H_2S) stripping using CO_2 or the stripping agent. The H_2S was then oxidised to elemental sulphur by passing the carrier gas through a ferric solution. The rapid kinetics of the various processes makes this proposal worthy of further investigation.

The occurrence of coagulation and flocculation, within the Rhodes Biosure® System, is presented considering some aspects of hydroxide/oxide and sulphide mineral precipitation chemistry using equilibrium and quasi-equilibrium chemistry. With regard to precipitation and recovery of metals – 2 important findings were identified. First, the flocculation effect observed in the Rhodes Biosure® System was found to be caused by a ferric / ferrous / sulphate / hydroxide – better known as Green Rust which is a meta-stable precipitant. This floc decomposes within a day to magnetite, haematite and other ferrous / ferric minerals. Further investigation into the decomposition process led the researchers to a unique method of producing magnetite (ferrite) from AMD waters, a process which works at ambient temperature using air as oxidant. This aspect has been further investigated under a separate WRC contract and the process patented by the WRC.

Cost: R280 000
Term: 1999-2000

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 3: Minimising the impact of waste on the environment

Closure planning in the minerals extraction industry: The role of effective waste characterisation and water-related impact predictions for solid mineral wastes
University of Cape Town
No 1550

There is great concern about the potential environmental impact of large amounts of solid waste produced by mining, most of which is consigned to land disposal. This continued generation of contaminated leachate from solid waste deposits that is in fact the most serious and pervasive environmental problem faced by the industry. This project aimed to enhance capabilities for the reliable quantitative prediction of water-related impacts associated with solid wastes from the mineral-based resource industries, and to provide a means of effectively integrating such information into decision-making processes relating to water-resource management.

The generic methodology that was developed to assess solid mineral waste impacts quantitatively consists of 6 systematic steps: problem formulation; qualitative waste characterisation; quantitative waste characterisation; leachate generation prediction; modelling of leached contaminants; and quantification of the impact. The proposed methodology for the prediction of solid mineral waste impacts was demonstrated for the case of porphyry-type copper sulphide tailings, which are representative of broad classes of minerals tailings. The case study has demonstrated the full capability

of the approach to environmental impact prediction developed in this project. The 'impacted land footprint' indicator is a predictive tool, and thus supports prospective decision making, across a variety of contexts – planning, design and operation. Its credibility lies in the fact that it is based on an holistic consideration of the full material life cycle of minerals – from ore extraction through to refining. Its value is reinforced by the fact that it can be used in generic situations, or, with suitable data, made site-specific. It provides a much more meaningful indicator of land- and water-related impacts from solid waste management practices than does any other indicator currently employed in environmental assessment. The increased understanding afforded by this approach provides opportunities to influence and control behaviour, and eventually optimise waste management and minimise environmental impacts across the entire life cycle of minerals' operations.

Cost: R655 000
Term: 2004-2006

Development of a first-order decision support system for the sustainable design, operation and closure of metalliferous tailings disposal facilities (S)
Golder Associates Africa (Pty) Ltd
No 1551

Mining of South Africa's gold, platinum and base metal resources has given rise to hundreds of mine residue disposal facilities (MRDFs). It is estimated that about 12 000 ha of land is sterilised by approximately 150 gold MRDFs within the Gauteng province alone. The legacy of the impacts associated with MRDFs has given rise to an increasingly complex regulatory regime. Approvals for upgrading old facilities, for development of new facilities, and for closure plans are difficult to obtain owing to the lack of a suitable framework within which to make decisions. This project aimed to develop a first order decision-support system (DSS) that would promote a coherent process to facilitate transparent and effective regulatory decision making.

The preliminary DSS that was developed as the main deliverable of this project provides support for decisions on water impacts and long-term surface stability associated with MRDFs. It is envisaged that subsequent versions of the DSS will include further modules on aspects such as air quality and socio-cultural impacts until eventually all relevant modules are included in a final system. The preliminary DSS comprises three components. The central component of the system comprises a top down hierarchy of questions within a rational framework. The hierarchy of questions are supported by two further components that provide users with decision guidance and decision criteria. The supporting components direct users through a series of logical steps to identify where the critical issues for each site specific situation lies. Regulators, proponents and consultants can use the system to better understand what questions need to be asked and answered. The DSS can be exited at any of the levels in the hierarchy with either a negative, positive or uncertain outcome. The depth to which the user must progress down the hierarchy of questions is a function of the level of complexity of the environmental setting and the risk associated with the facility. Broad issues are first addressed and dealt with at the top of the hierarchy whereas detailed questions are incorporated further down in the framework. The preliminary DSS is useful, provides a starting point for decision makers and should be issued as a working draft even though the final system is not in place. The DSS and in particular the protocol for providing new and promising technology is a new concept for the South African regulatory regime and holds promise for breaking through deadlocks that may arise on projects where current predictive methodologies and mitigation measures have not been proven in practice.

Cost: R600 000
Term: 2004-2006

Programme 4: Minimising waste production

Water conservation through energy conservation
Pollution Research Group, University of KwaZulu-Natal
No 1368

The overall aim of this project was to promote both water and energy savings in the South African process industry through more efficient use of process water and cooling and heating utilities. This was to be achieved by creating awareness of potential water and energy savings in the process industry and through the development and promotion of tools incorporating water and thermal pinch and mathematical modelling for the optimisation of water and heat exchanger networks. The approach taken in this study was to develop models of the interactions between various subsystems in the process industry and tools in the form of computer packages and graphical methods for their design and optimisation. The report is split in two parts detailing the work carried out by 2 independent research groups, Environmental and Process Systems Engineering Group at the University of Cape Town (UCT) and University of Pretoria (UP).

The UCT group worked towards the development of a methodology and tools for the analysis and design of systems in which the heat and mass exchanger networks are not independent, but interact with each other, with a view to being able to apply these techniques to systems in water conservation through energy conservation. Considerable progress has been made towards the objective of having a generalised methodology and tools to handle situations in which both heat transfer and mass transfer occur, but there remain areas that still need to be resolved. The UP group report on a case study of a site (Unit 11 at the African Explosives Limited (AEL) factory in Modderfontein) with the potential for water savings through the optimisation of the operation of the cooling circuit. The facility produces nitric acid, which is one of the intermediate products used in the production of ammonium nitrates, fertiliser and explosives for the mining industry. After assessing the site, the objectives of the project were adapted based on site specific observations and the inapplicability of the techniques currently available. Consequently, the investigation was focused on the low temperature end of the process, which involves a cooling tower and the associated cooling water network. During the course of the study, a cooling water network design was developed for systems with multiple cooling water systems. A cooling tower model was used to investigate the impacts of the new cooling water conditions on the performance of the cooling tower. Both research groups reported on significant progress but highlighted that further development and research is required.

Cost: R740 000
Term: 2002-2004

Characterisation of microbial populations and identification of dominant micro-organisms in different paper mill water systems
Dept of Microbial, Biochemical and Food Biotechnology, University of the Free State
No 1459

Paper mills in South Africa are under pressure to use less water than their counterparts in Europe and North America. Strategies to achieve this include the closure of water circuits to reuse water. Closure, however, directly and indirectly results in an increase in micro-organism populations. The objectives of this project were, to compile a database of micro-organisms and population characteristics in relation to physical properties of water systems, to establish a facility for routine identification of micro-organisms from industrial water systems and to train technical staff and students to provide a microbiological service to the pulp and paper industry.

Multiple correlation analyses showed that temperatures increases associated with mill closure could lead to increased microbial numbers and that microbial control must be considered when planning modifications to mills. The expected increase in chemical oxygen demand, nitrogen and phosphorous as result of recirculation could further increase microbial loads. An inverse relationship, observed between microbial numbers and oxidation-reduction potential, provides a technique for rapid assessment of microbial levels and, since oxidation-

reduction potential is also influenced by oxidising biocides, it could also indicate the levels of active biocide. Most of the environmental aspects had an influence on the microbial growth and diversity parameters and, since so many were involved, the highest single-factor correlations were between 0.3 and 0.4. The most prevalent bacteria were identified as members of the genus *Acinetobacter* and these strains were also the most widely distributed. The prevalent isolates from all surveys were characterised using Biolog® substrate-utilisation profiles and Restriction Fragment Length Polymorphisms (RFLPs). A facility for routine identification of micro-organisms from industrial water systems was established and used throughout the project, but maintenance of this laboratory cannot continue due to limited resources. Reference cultures and the database software have been supplied to Buckman Laboratories and the Department of Food Science (University of Stellenbosch) where it will be applied to further this objective.

Estimated cost: R 686 050
Expected term: 2003-2006

Development of a complete process integration framework for wastewater minimisation in multipurpose batch plants
University of Pretoria
No 1625

The approach followed was to employ mathematical programming principles, where the overall chemical plant is mathematically modelled. The objective is to maximise profit while minimising effluent. The development of the model was conducted while taking into account the current gaps in research and limitations of current methodologies so as to ensure that the overall methodology addressed the problems at hand. The mathematical model is based on mathematical programming principles using optimization as an underlying framework. The main contribution of the project was to treat both scheduling and wastewater minimisation as optimisation problems within a unified framework, which indeed proved more appropriate and optimal than published methods. The final stage was the application of the developed mathematical technique to a pharmaceutical production facility. This was done in three steps. The first step involved the application of a single contaminant methodology to the operation. The first step gave insight into the operation and the data that was required. From the first step it was observed that product and wastewater compatibilities needed to be taken into account. Based on this the multiple contaminant wastewater minimisation methodology with a single storage vessel was applied to the industrial site. This formed the second step of the application. During the application of the multiple contaminant model an important change came about in the sanitising method used. The chemical sanitising step was changed to a heat sanitising step. Based on this a final model was derived in the final step of the application of the methodologies. The final model schedules the production in such a manner as to maximise the amount of water that is reused, thus producing less effluent. The amount of water saved for each washout is dependent on the amount of water used for the sanitising step. The amount of water saved varies between 22 and 55%. The derived model finds practical application as it takes the current water usage into consideration. The output from the model was a production schedule. The production schedule shows the allocation of mixers to various products under the actual production requirements. Since water from the sanitising step goes to a central storage vessel, independent of the mixer, no extra pipe connections are needed to achieve water savings.

Cost: R198 000
Term: 2005-2006

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

Education, awareness and behaviour change requirements to improve safe water practices
Human Sciences Research Council
No 1522

Regulation in a democratic society cannot work independently of participation by citizens. Public agencies acting as regulators have to have the views of citizens to hand as it is their interests which are being protected. As the regulatory strategy in South Africa acknowledges, without this knowledge, regulation will have a limited impact. Internationally there is increasing interest in engaging poor communities and capturing citizen voice in scorecards as a step towards improving accountability between citizen and provider. Such participation should assist developing the regulatory framework in South Africa as communities understand the operation and standards of water services, voice their needs, and, as necessary, seek redress. The expression of voice is an integral aspect of a developed reflexive delivery system in which community voice operates as an important prod to municipalities acting as Water Service Authorities to respond to expressed need. Although greater attention to citizen voice is advocated, the challenge remains as to what method can be adopted to involve poor communities on the widest basis actively in people's regulation of water services?

The project has succeeded in providing a set of tools for community appraisal and engagement with the evolving regulatory system. New tools appropriate to the situation have been developed and existing community tools reshaped. These tools and community materials on water services are supported by an established training programme and strategy for spreading their use and techniques. The methods and materials have been developed in deprived and remote communities with the greatest challenges in water services and the tools have been shown to add data and value to community advocacy for better services.

Cost: R1 266 000
Term: 2004-2007

Health and hygiene education
Mvula Trust
No 1634

This study arose from a growing realisation that, in relation to water and sanitation infrastructure development projects, there is little consistency or coherence of approach to health and hygiene education (H&HE). As a result, many interventions are ineffectual. Further, the linkages between HIV/AIDS and the improvement of water and sanitation facilities and related H&HE are poorly addressed in this country. Accordingly, this study was established in order to clarify institutional arrangements and resources for project-based H&HE in the context of HIV/AIDS and to develop and refine for use within municipal contexts, models (covering institutional and financial arrangements) for implementing H&HE in water and sanitation projects.

An important principle that the study established is the value of keeping our institutional and financial arrangements simple, or rather to avoid complexity wherever possible. The principle that is followed is, therefore, to use existing resources and relationships, and to enhance and strengthen existing arrangements rather than to create new ones. All H&HE role-players in the sector must integrate issues relating to HIV/AIDS into their existing water and sanitation-related H&HE, and the sector needs to encourage and support this process, which is at present almost entirely absent.
The study highlights that user education and adoption of health-promoting hygiene practices should not be peripheral to infrastructure development, but should drive them. The report also makes a strong case for collaborative planning and collaboration of work efforts. It proposes the slogan 'joint planning and operational collaboration', which should be a guiding principle. It also proposes the establishment of coordinating forums at all levels, which would include the National Sanitation Task Team (NSTT) and the Provincial Sanitation Task Teams (PSTTs) but particularly at programme or district level and project level. The need for such collaborative structures for cross-sectoral, multi-group feedback

and collaborative project monitoring is emphasised, and specific advocacy interventions to achieve this are recommended. Training and standards of provision receive considerable attention in the report, and it is recommended, amongst others, that accredited training should be required of most major role-players, particularly ISD practitioners. It is also recommended that some form of association or professional body be established by ISDs to monitor and identify standards of provision.

Cost: R800 000
Term: 2005-2007

Programme 2: Peri-urban sanitation research

Drainage in rural and peri-urban townships
Water Systems Research Group, University of the Witwatersrand
No 1440

South Africa has a backlog in water services provision. In particular, drainage of low-income urban and rural townships has been identified as a problem. The cost of full services, including stormwater and water-borne sewage is beyond the affordability of many people, yet health and well-being are important for all. The study intended to identify the problems associated with drainage of low-cost townships in peri-urban and rural settings. It evaluated flows and water quality of sewage, grey water and stormwater in Alexandra Township, Kliptown, Madadeni and Kwamathukuza, an informal village in KwaZulu-Natal without services. Storm water has the greatest potential for picking up pollutants and transporting them to waterways resulting in pollution of potential water sources. That is because liquid streams, i.e. sewage and waste are usually well defined even if informal and it is a relatively simple matter to install drainage, whether it be surface channels or sub-surface pipes.

The study has found that solutions can be 'on site', or 'end of pipe'. Disposal on site is not possible in dense urban areas, but can be done in low-density (rural) environments. The volume and quality are of concern in dense settlements, but transportation and treatment is the problem in rural areas. Whereas sewage and grey water can raise health hazards if not disposed of correctly, storm-water also poses physical danger. Increased runoff is accentuated by denser buildings, which obstructs waterways. Flooding and property damage become worse due to rising flood levels and inability to evacuate. Blockage of storm drains by litter makes overflow worse. Structural end-of-pipe techniques are employed to treat residual effluent that cannot be cost-effectively controlled at source. Ranges of end-of-pipe control are available which aim to improve urban runoff. It is unlikely that there will be a single universal solution to all of the stormwater management issues. Hence an integrated suite of non-structural and structural management techniques will generally be required. This approach can achieve a balanced environmental and cost-effective outcome. The grey water samples from Alexandra, Klipspruit and Newcastle indicated that on-site, collective treatment of grey water and stormwater is possible, but sewage should be treated off site in dense settlements, whilst in low density rural settlements it can be treated in pits. Grey water can be led away in low-cost drains where necessary.
If water drainage is to be provided for all urban and rural residents, alternative solutions must be sought. Conventional separate sewers and storm drains are relatively expensive. The cheapest alternative is often grey water drainage, with onsite sewage disposal and surface stormwater discharge. But hygienic sanitation demands water borne sewerage or new approaches to black water disposal.

Cost: R520 000
Term: 2003-2005

Programme 3: Institutional and management aspects of sanitation service delivery

Knowledge/information management and advocacy
Hlathi Development cc
No 1635

A scan of international and national literature on sanitation, health and hygiene education and awareness shows that a lot of research has been done to address all the major issues that are responsible for poor progress in the reduction of the sanitation backlogs in the developing countries. Effective communication and dissemination of this information to decision makers and sanitation implementing agents remains a big challenge for the sanitation sector. The overall objective of this project was to improve dissemination of sanitation knowledge and information and to develop effective mechanisms/strategies for promoting the implementation of best practice by sanitation sector players.

Most developing countries still need knowledge sharing platforms that are not dependent on internet because of lack or poor access to electronic communication infrastructure in these countries. From the review of South African literature, it was concluded that internet alone could not solve the problem of knowledge and information dissemination to municipalities that are not connected to the information and communication technology (ICT) infrastructure. Innovative methods are required to enable the remote rural municipalities to access sanitation, health and hygiene education information and knowledge they need in order to accelerate sanitation service delivery to their communities. The literature review also showed that there were effective knowledge and information dissemination methods that could be used to disseminate sanitation knowledge and information to communities with low literacy levels.

Based on case studies it was recommended that knowledge sharing strategies need to be demand driven and requires institutional support. Such a strategy also requires coordination, local champions, quality control, adequate resource, monitoring, evaluation, and stakeholder involvement and ownership. The knowledge dissemination strategy must be aligned with the mission and vision of the organization and should be an integral component of the business strategy to ensure that it receives the same priority as other strategic objectives of the organisation; this would ensure that knowledge and information dissemination is mainstreamed instead of being treated as an ad-hoc activity. Two options for models of walk-in sanitation resource centres have been proposed as a suitable knowledge and information dissemination channels for end-users without access to the internet and ICT infrastructure. The principle of using existing institutions has guided the development of models for walk-in sanitation resource centres. A framework for a sanitation portal has been proposed as a knowledge and information dissemination channel for institutions that have reliable access to internet. The sanitation portal must provide relevant, reliable and high quality sanitation information. The sanitation experts must be appointed to manage the content of the information available on the sanitation portal and the sanitation information must be updated on a regular basis.

Cost: R300 000
Term: 2005-2006

Programme 4: Technical sustainability of sanitation services

Research into urine diversion toilets in eThekwini
University of KwaZulu-Natal
No 1629

Urine diversion (UD) systems have recently received a great deal of international attention in the context of 'Ecological Sanitation' or 'EcoSan'. EcoSan refers to a cycle, or closed-loop system, which treats human excreta as a resource. In this system, excreta are processed on site until they are free of pathogenic (disease-causing) organisms. Thereafter the sanitized excreta are recycled by using them for agricultural purposes.

Despite the obvious benefits of the design, there are a number of unresolved scientific, technological, social and health-related questions about how the design works from a biological and mass transfer perspective, and what the real health and

environmental risks are to the householder, community and any outsiders involved in the pit emptying process. The processes of drying and biological degradation which take place in UD vaults were investigated, with a view to understanding the characteristics of the UD waste at the time that the vault is to be emptied. The process of degradation in a UD vault was thought to be anaerobic biodegradation, with some aerobic degradation occurring at the air interface at the top surface of the waste; however, it was found that the conditions in the heaps are not conducive to anaerobic digestion. Because of the way in which the faeces and sand are added to the vault, the mixture is very non-homogeneous. Further the analysis has also highlighted the importance of the air circulation rate for achieving good drying. The fact that the Durban system is to close off the vault during the standing phase is therefore an unsatisfactory feature of the system, since it means that very little drying will occur during the standing phase. The risk assessment showed that there was a 31% reduced risk of diarrhoea in the areas where the on-site sanitation programme had been implemented to areas where it had not been implemented.

Cost: R600 000
Term: 2005-2007

Scientific support for the design and operation of ventilated improved pit latrines (VIPs)
University of KwaZulu-Natal
No 1630

This project proposed to undertake field and laboratory investigations of VIPs and their contents in and around the eThekwini Municipal area in order to understand the conditions found in the pits and to propose design and operating practice that will extend the life of pits. The standard VIP design was found to be effective for the accumulation and degradation of faecal sludge. However, it was observed that the ability of a VIP latrine to function as an improved sanitation system, i.e. to provide hygienic separation of human waste from human contact, to limit the transport of pathogens from human waste by vectors such as rodents and insects, to reduce nuisance associated with flies and odour and to preserve the dignity of the user, was compromised in a number of respects due to *poor construction, bad user habits, and during pit emptying operations*. It was observed that poor construction or lack of maintenance often resulted in essential features of the VIP latrine design being missing or damaged, including vent-pipes, fly-screens, pedestal lids, doors and back plates. Under these conditions, there were usually problems with odours and flies. Bad user habits resulted in rapid accumulation of pit contents, particularly when poorly degradable anal cleansing material such as magazines, plastic bags or stones were used. In many cases pit latrines appeared to double as waste disposal sites, resulting rapid filling of the latrines.

During pit emptying operations, significant risk of infection of workers and community members with human pathogens originating from the pit contents is expected due to difficulties in removing pit latrine contents and separating faecal sludge from solid waste. Examination of face masks worn by workers engaged in emptying pit latrines and screening the exhumed contents indicated that viable ova of a number of helminth species including *Ascaris, Trichuris* and *Taenia* spp. (roundworm, whipworm and tape worm) may be present in pit latrine contents and that these constitute a significant health risk to workers involved in handling pit latrine contents, and community members who have access to the area around the pit latrine during and after pit emptying operations.

Finally, commercial pit latrine additives were found to contain large concentrations of active micro-organisms with the ability to utilise organic substrates. However, neither the field trials, nor the laboratory trials provided evidence that the use of these products could result in a significant reduction in either mass or volume of pit latrine contents.

Cost: R600 000
Term: 2005-2007

CURRENT

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost recovery in water services

The development of models to facilitate financial sustainability of water services provision by Water Services Authorities in rural areas, based on an investigation of full costs and income
Mvula Trust
No 1614

This project aims to establish the real costs and income for providing water services in rural areas, using learning and applied research methodology of engaging and mentoring five WSAs. The identification of the costs and the model will further assist with good budgeting from all tiers in government and will contribute to some standardisation.

Estimated cost: R370 000
Expected term: 2005-2007

Programme 2: Institutional and management issues – Water services

Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas
Umgeni Water
No 1610

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and proven, which would then allow piloting and implementation much more attractive. The concepts will contribute to wider participation of small scale entrepreneurs in the management of water services.

Estimated cost: R600 000
Expected term: 2005-2007

Programme 3: Innovative management arrangements – Rural water supply

Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector
Council for Geoscience
No 1612

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made. This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralisation of services. Are these new arrangements supporting gender mainstreaming? This is what the study will be highlighting.

Estimated cost: R600 000
Expected term: 2005-2007

Productive use of domestic water for sustainable livelihoods
Nemai Consulting
No 1666

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional sources to improved water supplies and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor these additional

requirements of water for poor communities to be able to sustain their livelihood. Further the general approach and thinking to productive uses is limited to small-scale agriculture; however in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities and establish the levels of supply that will be adequate. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000
Expected term: 2006-2008

Programme 4: Regulation of water services

Review of regulatory aspects of the water services sector
AWI
No 1667

The changing water services institutional and legislative environment in South Africa has indicated the need for a strong and competent regulatory component to oversee the activities of the sector, such that objectives of sustainability, equity and efficiency are achieved and maintained. There had been many debates and discussions on this topic area, as to whether the regulatory function should be an independent function or whether the sector can afford a regulatory function and who will finance such an initiative, etc. DWAF has commissioned a number of studies in this regard, to address many of these queries and questions which have emerged. However, the subject area is very new to the sector and there is a great deal of information requirements to support decision making and input to support this regulatory function. The area also poses many challenges in its implementation. The study aims to support and build on national initiatives to find optimum models and mechanisms for effective regulation of the water services sector.

The study will cover:

- Review of international models for water services sector regulation and highlight pros and cons of the different regulatory models
- Assessment of institutional and human capacity required to implement sector regulation
- Evaluation of the cost implication of sector regulation on municipalities
- Exploration of the feasibility of using incentives to regulate the water services sector
- Investigate international best practice on proper regulation, identifying institutional, financial and operating procedures of relevance to South Africa
- Investigating and evaluating case studies of independent regulation and central regulation, capturing lessons and experiences of relevance to the South African situation
- Investigate water sector and consumer opinion on independent vs. central regulation and aspects that should be addressed
- Determine the scope of water services regulation and the linkage/integration with water resource management
- Identify the capacity and competency requirements to facilitate regulation across the sector
- Evaluation of the cost implication of water sector regulation and its impact on tariffs/chain of costs
- Exploration of the feasibility of using incentives to regulate the water services sector.

Estimated cost: R800 000
Expected term: 2006-2008

Programme 5: Impact of water and sanitation intervention

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa
Johannesburg University of Technology
No 1700

Over the years, the government has spent billions of rand to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental). Thus, the time is most appropriate for a study of this nature.

Estimated cost: R1 200 000
Expected term: 2006-2008

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Evaluating the potential for upgrading existing SA filtration plants to high-rate filters
Umgeni Water
No 1395

International experience indicates that gravity sand filters can be operated at filtration rates of up to 30 m/h. Standard practice in South Africa has been to design and operate filters at filtration rates of between 7 and 10 m/h. These are conservative filtration rates and are based on historical English and French design criteria.

The maximum filtration rate achievable in a filter is determined by its hydraulic design. However, the maximum rate which can be achieved before deterioration of filtrate quality or unacceptably short run times occur depends on the floc strength and filter media design (size and depth). High-rate filtration typically requires deeper beds and coarser media sizes than conventional rapid filtration and filter aid is often required to meet filtrate turbidity standards. However, in some cases it is found that existing filters operating at conventional rates can tolerate higher rates without any upgrades or changes in chemical pretreatment.

Sand filters contribute a substantial part of the total capital costs of water treatment plants. Upgrading existing filters to high-rate filtration as opposed to building new filters could potentially minimise or totally eliminate the need for capital expenditure on upgrading existing plant capacity. This in turn would have a direct impact on the water tariff being paid by the consumer. Once the maximum feasible filtration rate for various filters designs is determined, the potential for and costs of upgrading existing conventional filters to high-rate filters can be assessed.

Estimated cost: R208 000
Expected term: 2002-2004

An investigation into alternative methods to clean filter media in rapid gravity sand filters to ensure optimal performance and quality of the filtrate
Umgeni Water
No 1525

The project will establish a reliable procedure and protocol to measure cleanliness of the filter media, the behaviour of filter media, changes in head- loss, air and water scour rates and filtrate quality. The nature of deposits on the media will be determined in order to identify the mechanisms that cause media deterioration and extra-cellular microbial compounds

present in the deposit on the filter media rendering the medial sticky and difficult to clean will be determined. During the project, a representative survey of the SA water treatment plants will be conducted to bench-mark the efficiency of backwash procedures and media cleanliness, to determine the leading causes of media deterioration. It will also be attempted to quantify the potential savings that could be made by implementing the multi-cycle sequential and chemical filter cleaning procedures.

Estimated cost: R413 000
Expected term: 2004-2005

Biological filtration of iron and manganese from groundwater
Umgeni Water
No 1526

It is aimed to develop criteria for the design of biological filtration systems that will remove iron and manganese from groundwater in rural areas in an economical and sustainable fashion. The effectiveness of such systems will further be demonstrated by the operation of a small water treatment system in a rural area in KwaZulu-Natal.

Estimated cost: R750 000
Expected term: 2004-2007

Development of enhanced floating media separation for drinking water production and pretreatment in rural water supply
University of Stellenbosch
No 1527

The project proposes to further develop a filter with floating plastic media for the supply of water for rural communities. Performance of the filter both on its own, and as a pretreatment system for ultrafiltration membranes will be evaluated and the operability of the system will be compared to that of a conventional coagulation, sedimentation and sand filtration plant. This system should be a more efficient and cost-effective alternative to sand filters if the research is successfully executed. It is also simple to operate and requires less head for back-washing than conventional sand filters. A successful project can ensure that more small communities will have the benefit of membrane-treated potable water supply.

Estimated cost: R914 000
Expected term: 2004-2007

The defouling of membranes by moving magnetic dipole polymer beads, containing nano magnetic particles, in a scouring motion across the membrane using external magnetic fields
University of Stellenbosch
No 1592

Fouling of membranes remains the main problem preventing the large-scale and economic use of membranes in more applications internationally. Various chemical, hydraulic and ultrasonic membrane-defouling methods have been investigated, with varying success. This project aims to investigate nanotechnology for the in situ defouling of membranes. Nanomagnets will be incorporated into small polymer beads and the magnetic fields in all of the nanomagnets inside the beads will be aligned. Movement of the polymer beads on the surface of the membrane will then be induced in order to scour the surface, which will hopefully clean and prevent fouling on the membrane surface. The resulting system will be evaluated on a typical coloured surface water purification application.

Estimated cost: R794 000
Expected term: 2005-2008

Development of improved local anti-fouling spiral wrap membranes
University of Stellenbosch
No 1593

This work will build onto the ongoing research in innovative defouling methods investigated at the Institute for Polymer Research at the University of Stellenbosch. These local innovations, as well as appropriate international developments, will be incorporated into a locally manufactured spiral wrap membrane. A number of trial membranes will be produced and bench-marked against existing membranes. Guidelines for the manufacture of these improved spiral membranes will be provided to the South African membrane industry.

Estimated cost: R720 000
Expected term: 2005-2008

The generation of design parameters for the use of the limestone teeter-bed reactor for potable water stabilisation and the treatment of Cape coloured waters
RG Batson
No 1594

The project entails the further development and assessment of an improved limestone reactor for the treatment and stabilisation of coloured surface water. A fluidised bed reactor is required when using limestone, since colour and metals in surface water tend to coat the surface of limestone particles, rendering the reactor inefficient after a relatively short operating time. This patented system aims to overcome the disadvantage of fluidised bed reactors in terms of unacceptably high energy consumption, while still ensuring the required scouring action of the limestone particles in order to keep them from becoming coated. The technology will be evaluated and demonstrated on a typical soft, corrosive, Cape Province coloured water.

Estimated cost: R390 000
Expected term: 2005-2007

Operational strategies for the cost-effective use of ozone in water treatment
Umgeni Water
No 1596

The aim of this project is to study the factors that affect ozone demand with a view to optimise ozone dose and determine the impact of ozone on downstream processes and downstream water quality. Suitable determinants will be used to optimise ozone dose on three chosen full-scale plants currently using ozone treatment. An analytical test kit for optimising ozone dose will then be tested in each of the three plants with a view of adapting the procedure for each of the three situations. Control strategies for ozone dose optimisation for changing raw water qualities including flows and other operational issues will be developed so that it can be integrated into the general waterworks control system.

Estimated cost: R651 500
Expected term: 2005-2007

Programme 2: Water treatment for rural communities

Technical and social acceptance evaluation of a novel microfiltration and ultrafiltration membrane system for potable water supply to rural and remote communities
Chris Swartz Water Utilization Engineers
No 1227

The project entails the evaluation of locally developed membrane systems for the production of potable water for small communities from a variety of surface water qualities found in South Africa. The evaluation will be performed using both ultrafiltration and microfiltration mobile treatment systems. Guidelines for the application of these membrane systems to specific surface water qualities will be drafted. The project scope includes operational guidelines for potential users as well as the establishment of social acceptance factors of the technology with rural communities.

Estimated cost: R556 000
Expected term: 2001-2004

Development of appropriate brine electrolysers for disinfection of rural water supplies
Department of Chemistry, University of the Western Cape
No 1442

Chlorine disinfection is required for rural water treatment since it has residual disinfecting powers after water has been carried into the homes. This project will further develop a novel system for the generation of chlorine from common table salt. The unit to be developed will not produce toxic chlorates as side-products – as can easily happen when employing currently available salt chlorinators. The unit will further allow pH control of the dosed chlorine liquid, allowing much more efficient disinfection and is a main advantage over the current systems.

Estimated cost: R480 000
Expected term: 2003-2005

The testing of a membrane technology unit for the removal of nitrate, chloride, phosphate and sulphate pollutants from groundwater (NS)
University of the North West
No 1529

The project aims to evaluate a number of different membranes for the removal of salts and specific pollutants from groundwater sources in the North West Province. The project also aims to assist in the training of local people (technicians) to operate and maintain the water processing installation and monitor impurities on-site with field testing equipment. The consumers' understanding of the implementation of a water purification system through examining the following:

- The knowledge of consumers regarding purified water and the purification system
- Their attitudes towards purified water and a purification system will further be determined.

Such membrane systems established in the rural areas will contribute to a healthier life, especially for people living in high nitrate groundwater areas.

Estimated cost: R499 600
Expected term: 2004-006

Assessment of the occurrence and key causes of drinking water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof
Emanti Management
No 1597

Small water service providers are having problems in proactively managing drinking water quality within their distribution networks. This project aims to analyse the relatively high percentage of water quality failure in two provinces of South Africa and in particular contrast the water quality at the water treatment plant with that at point of use. Guidelines will then be developed for the management of drinking water quality in non-metropolitan distribution systems. The guidelines will include legislative compliance requirements, technical inputs (e.g. optimum free chlorine residual levels), best practices (e.g. pro-active maintenance requirements), monitoring and management protocols and reporting protocols to consumers, provincial and national government. These guidelines will then be used in a 'road show' to make the appropriate officials aware of the need for effective monitoring and management.

Estimated cost: R452 300
Expected term: 2005-2007

The development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters
Durban Institute of Technology
No 1598

This proposed project will focus on developing the local woven fibre immersed membrane micro-filter into systems for the pretreatment of high turbidity surface waters as well as the gravity-fed treatment of water in remote regions. The project will complement and enhance the applicability of other local technological developments in rural water treatment, e.g. the locally developed capillary ultrafiltration system. The project will develop a standard membrane pack for immersed microfiltration membrane applications. Different configurations and operating protocols will be evaluated so as to minimise fouling and maximise ease of cleaning. A simple, gravity fed water treatment system for water provision in remote areas will be demonstrated.

Estimated cost: R765 000
Expected term: 2005-2008

A manual and training aids for operation and maintenance on small water treatment plants
CD Swartz
No 1599

In a study of 20 small water treatment plants WRC *Report No. 738/1/00* entitled Guidelines for the Upgrading of Small Water Treatment Plants) it was found that most local small water treatment plants experience problems in operating on a sustainable basis. This was due to a number of both technical and human factors. However, due to the wide and encompassing nature of this investigation, it was not possible to identify and characterise the operation and maintenance-related problems fully. This project, therefore, aims to survey current management practices, determine optimal small plant operation and management methodologies for South Africa and compile a user-friendly operation and maintenance manual. Based on the manual, training aids will be developed and this knowledge will be disseminated by means of a 'road show', demonstrating the training aids.

Estimated cost: R1 500 000
Expected term: 2005-2008

Compliance of non-metropolitan South African potable water providers with accepted drinking water quality and management guidelines and norms
University of Fort Hare
No 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other, operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers that are preventing compliance to these guidelines and norms, and communicate these solutions to the municipal management authorities. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000
Expected term: 2006-2009

Investigate the state of plumbing used in South Africa
University of the Witwatersrand
No 1701

The project will investigate the state of plumbing used in South Africa and provide guidelines for the appropriate use of plumbing and components to ensure correct application and optimum cost-benefit values, also in the long term. The investigation will include the effect of not using plumbing material components complying with minimum national standards, nor installed according to installation and design codes of practice; product performance standards for showers, aerators, flow restrictors, dual flush toilets, low flush systems, etc.; condition of retrofitted products and the effect and suitability of high-pressure domestic plumbing systems on product life performance and system life, water wastage and system performance.

Estimated cost: R600 000
Expected term: 2006-2008

Assessment of the feasibility of using a dual water reticulation system in South Africa
University of Johannesburg
No 1702

The option of dual reticulation, that is supply of different qualities of water, for drinking and flushing/gardening, continues to receive a great deal of queries from a high political level to a local level. Much work has been done on this subject at an international level, and at a local level the option has been investigated in the past. The verdict was that it was not a favourable option due to costs and management constraints. However, the technology has evolved since then and great strides have been made on the subject. With the current and future challenges facing South Africa the opportunity exists to revisit the subject area and determine the state of knowledge and its applicability to South Africa.

Estimated cost: R 600 000
Expected term: 2006-2008

Programme 3: Drinking water quality

Methods manual for monitoring phytoplankton and cyanobacteria
Rand Water
No 1533

The project will compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins, Geosmin and MIB for South African freshwaters Current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis, as well as for Geosmin and MIB analysis will be synthesized and a summarised reference document compiled.

Estimated cost: R403 600
Expected term: 2004-2006

New detection methods for EDCs
University of Stellenbosch
No 1534

The project will aim to produce and test an endocrine disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand binding domain (LBDER) into a suitable yeast (Pichia pastorus) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotynilation of LBDER and preparation of biotynilated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialised polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection.

Estimated cost: R647 500
Expected term: 2004-2007

National standards for water and wastewater treatment chemicals
Umgeni Water
No 1600

The national standards for many water treatment chemicals in everyday use are out-dated and describe analytical procedures which are in some cases obsolete and very time consuming. In addition to this, there are many water treatment chemicals for which no national standards exist, in spite of the fact that some of these are used extensively in the water and wastewater treatment industry. Therefore, this project aims to evaluate current South African standards and international standards for water and wastewater treatment chemicals; assess the needs of the industry in terms of national standards for water and wastewater treatment chemicals; and produce a report containing recommendations which will serve as the basis for the up-dating and re-issuing of current standards and for the creation of new standards where these do not currently exist.

Estimated cost: R241 800
Expected term: 2005-2007

Programme 4: Water distribution and distribution systems

Grouted lining systems for the renovation of old steel pipelines and the design of new pipelines
Rand Water
No 1448

Steel pipes are used extensively in SA and need to be protected against corrosion, hence the need for internal linings and external coatings. In pressure pipes there are many problems associated with the use of grouted-viscous-elastic linings at joints, bends and fittings, etc. This study aims, through laboratory trials and investigations, to provide solutions to this unresolved problem experienced by water suppliers, which costs them large sums of money due to failures.

Estimated cost: R736 300
Expected term: 2003-2006

THRUST 3: WASTEWATER AND EFFLUENT TREATMENT AND REUSE TECHNOLOGY

Programme 1: Biological sewage treatment processes

Practical implementation of external nitrification in biological nutrient removal activated sludge systems
Division of Water Quality Engineering, University of Cape Town
No 1262

In this project, full-scale trials are being run on external nitrification in biological nutrient removal activated sludge (BNRAS) systems to test the fundamental, laboratory-scale and economic studies done to date by this research group, which have shown that external nitrification in BNRAS systems can be a more efficient and cheaper (20 to 25% lower) alternative compared to other BNRAS systems covering both green-fields and retro-fitting situations. In this collaborative exercise between UCT, the Cape Metropolitan Council, and Water & Sanitation Services SA (Pty) Ltd (the local agent for CIRSEE/Suez Lyonnaise-des-Eaux), the cash contributions by others (excluding contributions in kind) amount to about 40% of the total budget.

Estimated cost: R1 280 000
Expected term: 2001-2005

Biofloc modifications for sludge settleability improvements from selected BNR process conditions and configurations, pilot- and full-scale based settling behaviour evaluations for final clarification enhancement
ERWAT
No 1340

Recent new DWAF legislative standards include lower permissible suspended solids and nitrate concentrations in effluents. Limited research has been done to determine the optimum levels of aeration necessary to keep solids in aerated suspension and produce the required flocculation. Alongside this, current biomass settling models are empirically based, the mechanisms postulated are not supported by representative plant data, and the settling process is very sensitive to variable process conditions and environmental factors. In this project a pilot plant will be operated to generate benchmark data which will be used to configure a comprehensive mathematical model describing both sludge settleability and settling behaviour. The pilot-scale tests will be conducted in parallel with full-scale verification trials at various ERWAT wastewater works.

Estimated cost: R298 330
Expected term: 2002-2004

The production of aerobic granular activated sludge for enhanced settling in sewage treatment
BKS (Pty) Ltd
No 1451

Building on previous work carried out by the group on a synthetic (acetate) substrate, this project aims at the systematic selection of granulated aerobic sludge in a sequencing batch reactor process treating sewage. If successful, the overall process efficiency would be significantly enhanced by improving the sludge settleability. Some similar work has been carried out overseas and the innovation level is relatively modest but equally the risk is reduced.

Estimated cost: R327 800
Expected term: 2003-2006

To investigate the performance and kinetics of biological nitrogen and phosphorus removal with ultrafiltration membranes for solid-liquid separation
University Cape Town
No 1537

This project is a follow-on to **WRC Consultancy No 514** which was specifically commissioned as a 1-year feasibility study in 2003 to test whether nutrient removal could be accomplished in this type of robust, low-cost sewage treatment system which is independent of the sludge bulking problems which in turn often compromise the effective performance of activated sludge processes. The low pressure-drop ultrafiltration (UF) membranes being used are supplied and funded for this purpose by the suppliers (MembraTech, UK). Recent information (November 2003) indicates that the process is operating satisfactorily. On the basis that the preliminary promise has been delivered, a fuller investigation is therefore required to provide a rigorous and definitive examination of this type of system. A parallel 'next step', which is already in hand, will be to investigate whether UF membranes of similar or superior performance can be locally sourced, and/or designed and manufactured.

Estimated cost: R1 132 400
Expected term: 2004-2006

Development of a commercially viable implementation model for anaerobic co-digestion of toxic and high strength organic waters
University of KwaZulu-Natal
No 1538

This project builds on 2 previous **WRC Projects**, namely **No 762** which assessed the viability of using anaerobic digestion to treat refractory textile wastewater and **No 1074** which investigated co-digestion of these wastes with domestic sewage on a regional basis. The outcomes of these base studies were positive and the present project seeks to extend the technical success achieved into a practical technology-application scheme. In collaboration with Durban Metro (Water and Waste), a commercially-orientated survey will be carried out to quantify specific industrial sources, loads, sewage works capacity and costs (capital and running) for operating the scheme. These results will be drawn together into a multi-stakeholder business plan aimed at meeting the needs of industry, regulators and sewage treatment plant operators. It is significant that previous WRC research, regulator buy-in and progress made with industry with regard to cleaner production have come together to create this window of opportunity.

Estimated cost: R150 000
Expected term: 2004-2005

IAPS algal biomass and treated effluent utilisation as a key strategy in sustainable and low-cost sanitation
Rhodes University, Centre for Entrepreneurship in collaboration with Sustainable Environmental Technologies
No 1619

Historically, the focus in sewage treatment in the RSA (in line with much of the 'developed' world) has been to seek 'efficient' end-of-pipe processes for converting the organic and inorganic residuals of human diets to end-products that are (superficially) more environmentally neutral – carbon to CO2/CH4, nutrients (e.g. N & P) to non-eutrophying compounds, etc.). Simultaneously, as global food demands increase, these same compounds constitute valuable agricultural resources. This project targets this strategic niche, by firstly capturing sewage nutrient-values in algal form and then applying the product as a fertilizer for food production. This approach creates a barrier between sewage treatment and crop production to control the potential health risk (the major problem with direct reuse of sewage wastewaters), but without seeking to 'destroy' the nutrient) values in the wastewater stream. The specific aims of the project are to investigate uses of algal biomass from integrated algal ponding systems (IAPS) in value-chain crop production and horticultural applications, to determine the role and mechanisms of IAPS algae in plant growth stimulation, to evaluate different methods for efficient harvesting and recovery of algal biomass from IAPS, and to carry out a preliminary economic feasibility study and business plan development for implementation of such schemes at IAPS treatment works. The project thus also has strong elements of interventions for effective and practical poverty alleviation.

Estimated cost: R395 200
Expected term: 2005-2007

Materials mass balances modelling of wastewater treatment systems
University of Cape Town, Department of Civil Engineering
No 1620

This project follows on **WRC Project No. K5/1338** in which the novel and far-reaching integrated chemical/physical/biological process modelling approach for biological waste treatment processes was developed and confirmed. In the new project, the overall aims are to:

- Develop a mass-balance-based steady state model for wastewater treatment plants (WWTP) for preliminary design and operations overview
- Develop a kinetic simulation model that integrates the mixed weak-acid/base chemical, physical and biological processes for detailed design, dynamic simulation, process operation and optimisation.

These 2 aims represent high-end long-term objectives that require closing of several important knowledge gaps with experimental research at laboratory and full-scale supported by theoretical modelling. The project has far-reaching implications with significant spin-off benefits for other WRC research projects, as already demonstrated in the previous **Project No 1338** which is delivering modelling of activated sludge, algal ponding, and methanogenic and sulphidogenic anaerobic digestion processes.

Estimated cost: R720 000
Expected term: 2005-2007

A status quo assessment of the effectiveness of wastewater pond systems for containment and treatment of wastewaters, and the development of practical operating guidelines
Emanti Management (Pty) Ltd
No 1657

In various parts of the RSA, algal ponding systems constitute a significant proportion of the installed capacity for sewage treatment and have generally been effective in limiting environmental pollution and associated health impacts. In a preliminary study of waste-stabilisation ponds recently commissioned by the Free State DWAF office, the current status of waste-stabilisation ponds in the Free State was documented. Some of the key findings from the study were that the pond systems were generally well-designed and showed good operational performance, but scored very poorly in terms of maintenance, safety and supervision/management. A simple strategic decision-support tool was accordingly developed to guide future interventions. Considering that the above situation is not only limited to the Free State but is commonplace throughout the RSA, there is a need to document the

occurrence of pond systems throughout the RSA, investigate their current operational status and practices followed, identify in what instances the technology is applicable or whether alternative technologies should be considered, identify how operation and maintenance (O&M) of these systems can be improved (through capacity building, technical guidelines, monitoring, etc.), and assess the potential for reusing treated effluent from pond systems. These aims are addressed in this project, using the Free State and the Eastern Cape as case-study areas. Guidelines will be prepared highlighting O&M procedures, common issues of concern, best practice techniques, criteria for selection of treated effluent for reuse purposes and criteria for selection of alternative technologies (if applicable). The existing MS Excel-based strategic support tool will be updated and further developed to a web-based format, allowing easy access to pond system information for all relevant stakeholders.

Estimated cost: R700 000
Expected term: 2006-2008

Evaluation of a South African clinoptilolite for ammonia-nitrogen removal from secondary sewage effluent for pollution control
University of Pretoria, Deptartment of Chemical Engineering
No 1658

Ammonia discharged into the water environment accelerates eutrophication of dams and depletes dissolved oxygen in receiving waters, and, in its undissociated form, is also toxic to fish even at low concentrations (0.5 mg N/ℓ). The current discharge limit for ammonia-nitrogen (NH_3-N) in treated sewage effluent is 10 mg/ℓ (likely to be reduced to 6 mg/ℓ in the near future). At many wastewater works in the RSA, particularly in winter when biological activity slows down because of lower temperatures, it is difficult to produce treated effluent containing less than 10 mg/ℓ NH_3-N by the usual biological nitrification process, with consequent negative environmental and ecological impacts. As an alternative or stand-by process, absorption of NH_3-N by clinoptilolites (naturally occurring zeolites) has potential as an effective low-cost means for final polishing of treated sewage to reduce NH_3-N to acceptable levels. Previous work in this regard has been carried out using imported clinoptilolites, with cost and forex implications, and knowledge is needed in the RSA on the performance of the locally-mined clinoptilolite for removing NH_3-N from treated sewage. The aims of this project are to determine the performance of local clinoptilolite for removing NH_3-N from treated sewage effluent on laboratory- and pilot-scale, to determine the efficiency of ammonia recovery from the spent regenerant, to develop appropriate process design criteria and costs, and to develop an operational and maintenance manual for the process.

Estimated cost: R317 000
Expected term: 2006-2008

Design Manual for Small Sewage Treatment Works
Waterscience cc
No 1660

Many of the 1 500 (approximately) sewage treatment plants in the RSA are classified as 'small' works. The existing manual for the *Design of Small Sewage Treatment Works* was prepared by the Institute of Water Pollution Control (IWPC) some 20 years ago and is in need of updating as several new processes are available and the understanding of the activated sludge process, in particular, has advanced significantly since then. The manual also does not consider processes used in small plants of the package plant type as are commonly used in housing complexes. With technological advances and a number of changes in the procedures used in plant operation, a new manual covering these changes is required. The aims of this project are to evaluate current wastewater treatment practices used in the RSA and internationally for small sewage treatment plants, produce a design manual for such plants, and conduct workshops to disseminate the information included in the manual as part of capacity building.

Estimated cost: R250 000
Expected term: 2006-2008

Support to EU – EUROMBRA project: Development of an anaerobic membrane bioreactor
University of Natal/Pollution Research Group
No 1661

The highest development priority in the RSA water sector at present is the provision of affordable but safe community wastewater treatment (MDGs, etc.) and particularly also to provide a barrier against the transmission of water-borne diseases in the context of a population which is immunologically challenged and under-nourished. Aerobic treatment systems, other than algal ponding systems (which however have a land footprint not suitable for urban or peri-urban situations) require a significant and probably unsustainable energy and/or chemical input to be effective in terms of the treated water quality achieved. Anaerobic systems have a significantly lower resource requirement, but to date have not been able to produce the microbiological water quality required for community health safety and concomitant quality-of-life. This project targets this problem, using an innovative approach based on established anaerobic treatment technology enhanced by the use of membranes (which over the past few years have become sustainably affordable and increasingly robust in their performance, with the major and strategic benefit of providing a physical barrier to microbial passage). The research issues addressed are the basic system performance and the requirement to limit membrane fouling and/or to develop a membrane-cleaning regime that does not require external energy inputs. If successful, the system would have an immediate and major impact on the provision of low-cost and safe sanitation to a range of communities in the RSA. This project supports an EU programme, and the potential for roll-out to a wider base, e.g. SADC/Africa/developing world, is thus strong.

Estimated cost: R693 280
Expected term: 2006-2008

Programme 2: Sludge characterisation, treatment, utilisation and disposal

Scale-up development of the Rhodes BioSURE™ process for sewage sludge solubilisation and disposal
Department of Biochemistry, Microbiology and Biotechnology, Rhodes University
No 1336

The overall aim is to derive process design criteria for full-scale implementation of the Rhodes BioSURE™ process for sewage sludge solubilisation. To achieve this, the demonstration-scale BioSURE™ plant established at Ancor Sewage Works (Springs) will be operated, monitored and optimised, and the facility will be extended to include sulphide bio-oxidation and sulphur recovery. A smaller pilot plant at Makana Sewage Works (Grahamstown) will be operated and monitored to study process variables in finer detail, to identify and investigate areas of sulphidogenic sewage sludge solubilisation that require further development for scale-up.

Estimated cost: R1 510 900
Expected term: 2002-2005

Influence of sludge conditioners on the soil conditioning properties of sewage sludge
University of Pretoria
No 1540

This project aims to determine the influence of sludge conditioners used during sewage treatment processes on the soil conditioning properties of sewage sludge.

Estimated cost: R101 000
Expected term: 2004-2006

Development of the South African wastewater sludge disposal guidelines dealing with land and ocean disposal, beneficial use, use in commercial products and thermal treatment
Zitholele Consulting (Pty) Ltd
No 1622

Soon after the publication of the 1st edition of the guidelines on the *Permissible Utilisation and Disposal of Sewage Sludge* in 1997, the WRC embarked on a process to revise these guidelines. A research programme was initiated to characterise South African wastewater sludge and better understand sludge disposal practices in order to develop a local knowledge base and a better appreciation of the issues that should form the basis for a comprehensive revision of the 1997 Guidelines. An Addendum to the 1997 Guidelines was published in 2001 to clarify and elaborate on certain issues where this was required. A start with the development of the 2nd edition of the *South African Sludge Guidelines* was made in 2003. This initiative saw the publication of the first two volumes (a general overview document and guidelines for beneficial agricultural use) of the new guidelines in 2006. The current project, which is being co-funded by DWAF, will complete the process and produce a further three documents, which will give guidance for:

- The non-beneficial disposal of wastewater sludge by employing options such as dedicated land disposal, landfills, lagoons and ocean discharge
- The beneficial use of wastewater sludge at high loading rates in agriculturally related practices, such as mine tailing rehabilitation, nursery growth material and landfill capping
- The production of commercial products such as bricks, cement and fertilisers as well as thermal treatment of wastewater sludge.

Estimated cost: R1 428 800
Expected term: 2005-2008

Programme 3: Treatment and recovery of organics from agro-industrial processing

Development of a hybrid immersed-membrane bioreactor
Institute for Polymer Science, University of Stellenbosch
No 1369

The project is aimed at producing an innovative immersed membrane bioreactor for potential use in the treatment of wastewaters as well as for potable water production from dirty surface water sources. This technology has particular potential for smaller systems. This project will take development to prototype stage. The product will combine the advantages of the newly developed immersed membranes with a novel cleaning, biofilm control and oxygen supply method. This technology has great potential in South Africa and elsewhere in the world, because it is expected to improve significantly on the current immersed membrane efficiencies, coupled with a lower potential for fouling and lower maintenance and general attention requirements.

Estimated cost: R990 000
Expected term: 2002-2005

The removal of reactive dyes from dye liquor for the reuse of salt, water and energy
Pollution Research Group, University of KwaZulu-Natal
No 1542

The textile industry needs cost effective, low environmental-impact processes to remove colour and salt from their effluent. The project is for the treatment of concentrated reactive dye effluents from the textile processing industry at source using activated carbon. The high salt concentration shifts the equilibrium towards the carbon, resulting in very high removal efficiencies. The project will combine life cycle assessment (LCA), chemistry and process engineering considerations to develop an important recycle technique for the textile industry, in order to recover and recycle chemicals and consequently reduce the waste loads generated. This is a good reduction-at-source approach towards developing a solution to the problem.

Estimated cost: R272 600
Expected term: 2004-2006

Industrial wastewater remediation via wet air oxidation using immobilised transition metal catalysts
University of the Western Cape
No 1543

Aqueous effluents from the chemical and related industries contain various organic pollutants which are toxic and refractory and occur in concentrations too low for economical recovery but too high for conventional biological treatment. This project aims to investigate and develop catalytic wet air oxidation as a technology for treating such effluents.

Estimated cost: R600 000
Expected term: 2004-2006

Programme 4: Treatment and recovery of inorganics (including sulphate and metals) in industrial and mining effluents

Investigation and development of the biotechnology of sulphur biofilms in the beneficiation and treatment of wastewaters
Rhodes University
No 1545

The WRC has made a substantial investment in sulphur systems biotechnology for the treatment (active and passive) of acid mine drainage AMD and certain industrial wastewaters. Biodesalination of these wastewaters requires that sulphur-derived TDS be finally removed from the treated stream, but effective sulphur removal remains a technological bottleneck in these processes. This project seeks to further develop a sulphur-removal system based on sulphide bio-oxidation carried out in floating biofilms. This is a core technology in overall AMD bio-treatment processes and the project supports and extends current work being carried out in **Project No 1456**.

Estimated cost: R924 810
Expected term: 2004-2006

Development of sustainable low-cost management for saline sewage and saline mine drainage wastewaters using integrated algal ponding systems
Rhodes University, Environmental Biotechnology Research Unit
No 1621

The WRC has invested substantially in the development of sustainable management technologies for saline wastewaters from a range of sources including industry and mining. One specific innovation involves the use of ponding systems for the treatment of mine drainage wastewaters in the *Algal Sulphate Reducing Ponding Process for Acidic Metal Wastewater Treatment* (ASPAM®) which was preliminarily investigated at bench-scale and reported on (*Report No TT 192/02*). The mining industry has identified the importance of the general approach and has requested evaluation of the process at pilot-scale with a view towards full-scale implementation. The aims of this project are accordingly to undertake pilot-scale process development of the WRC-patented ASPAM® system using algal ponding for low-cost sustainable treatment of metal-contaminated acidic sulphate-saline wastewaters, including investigating factors relating to the linkage and integration of the various unit operations of the process, determining kinetic values and design parameters required for full-scale implementation, undertaking a fundamental

investigation of the algal proton-absorption capacity of the ASPAM® system underpinning the metal precipitation and neutralisation unit, characterising fundamentally the sulphur biofilm formation operation, and developing a descriptive model for the system.

Estimated cost: R1 139 700
Expected term: 2005-2007

Continued evaluation of the integrated managed passive water treatment system (IMPI), long-term monitoring of VCC passive treatment plant and three-dimensional characterisation of decommissioned sulphate reducing units
Pulles, Howard and de Lange Inc
No 1623

In the RSA a sustained 9-year research programme with a 2004 value of around R21m. (from various funding sources) has aimed at developing passive water treatment technology that can reliably remove sulphates, acidity and metals from AMD waters. This research effort has resulted in the development of a **degrading packed bed reactor** that is a world leader in volumetric sulphate removal rates from mine-waters, by almost an order of magnitude compared to other international technologies. A key feature of the technology is that it will generally be required to operate for a number of years, typically decades, and continue to perform in accordance with its specified duty. A strategic concern of the mining industry and the regulatory authorities relates to the confidence that can be placed in the long-term performance of such units and their eventual fate. As a logical final stage in developing and evaluating passive treatment processes, this project will extend and intensify the monitoring of existing passive AMD treatment plants while at the same time de-commissioning and autopsying other similar long-running units.

Estimated cost: R400 000
Expected term: 2005-2006

Programme 5: Training in wastewater treatment plant operation

Development of a diagnostics-based knowledge management system for the efficient operation and training of staff associated with municipal sewage treatment facilities
Department of Biochemistry and Microbiology, Rhodes University
No 1337

Pressures of rapid urbanisation and the provision of sanitation services have resulted in sewage treatment plants operating sub-optimally for a variety of reasons including not only installed hardware capacity but also insufficient operator training and expertise for consistent management of the facilities. This project aims to support and strengthen the human resource base by generating a knowledge management database for capturing the experience of operators and engineers in running sewage treatment facilities; developing and applying a system for implementation of the database; and testing the system initially at a sewage treatment facility in the Port Elizabeth Municipality.

Estimated cost: R329 200
Expected term: 2002-2004

Programme 6: Biotechnological co-treatment of saline and sewage wastewaters

Biotechnological co-treatment of saline and sewage wastewaters with integrated recovery and reuse of water and organic and inorganic components for sustainable development:
Part 1: Saline sewage treatment
Part 2: Biosulphidogenic sewage treatment
Part 3: Hybrid systems for treating acid mine drainage
Part 4: Integrated community benefit
Dept of Biochemistry and Microbiology, Rhodes University
No 1456

The overall objective is to exploit and further develop beneficial applications of biotechnological processes for co-treating saline and sewage wastewaters in the sustainable and integrated management of various water-related community, industrial, agricultural and environmental needs. The specific research objectives are to determine the economic, social, technical and technological feasibility of a biological process for treating sewage reticulated in saline water, including nutrient removal and disinfection, for urban and rural communities (the 'Saline Sewage Treatment' component); develop, test and demonstrate processes for biological treatment of effluents from the bio-sulphidogenic co-treatment of mine-water and sewage sludge to standards suitable for a range of subsequent beneficial uses, and biotechnological oxidation and recovery of sulphur from such systems (the 'Bio-sulphidogenic Sewage Treatment' component); develop, test and demonstrate hybrid active-passive systems for sustainable treatment of acid mine drainage before and after mine-closure (the 'Hybrid Systems for Treating Acid Mine Drainage' component) and develop integrated social responsibility/community components for employment opportunities, job creation, and other community upliftment benefits derived from the biotechnological applications envisaged (the 'Integrated Community Benefit' component).

Estimated cost: R3 000 000
Expected term: 2003-2005

Programme 7: Sewerage reticulation

A first-order national audit of sewerage reticulation issues
Industrial and Urban Infrastructure (Pty) Ltd
No 1671

According to research needs analyses a range of issues relating to stormwater control and management require to be researched. The issues concerned range from strategic aspects such as norms and standards for stormwater management for informal and/or temporary settlements to more specific technical issues such as the need or otherwise for stormwater treatment before discharge, associated health concerns, the potential for stormwater reuse, e.g. for selected industrial uses, flood peak-to-average ratios, etc. This solicited project will aim at identifying, characterising and prioritising stormwater management issues requiring attention in human settlements, and developing strategic guidelines for dealing with these.

Estimated cost: R400 000
Expected term: 2006-2007

Programme 8: Stormwater management

Biotechnological co-treatment of industrial/mining effluents with sewage wastewaters
SRK Consulting
No 1670

Sewerage reticulation systems represent a considerable capital investment in the overall provision of waterborne sanitation. Apart from recent research into developing technical alternatives to the conventional gravity sewer such as small bore ('solids-free') sewers, shallow sewers and vacuum systems, the sewerage systems responsible for receiving and reticulating sewage flows have received less attention than other sanitation issues. In this context the sanitation system employed is of obvious relevance, e.g. whether conventional waterborne, low-flush waterborne, or urine-diversion types, etc. From interactions over a period of time with a number of key stakeholders, it appears that the state of current, up-to-date knowledge is inadequate around a range of issues regarding sewerage reticulation in the RSA. This solicited project is being commissioned by WRC to provide a first-order assessment of the sewerage situation in the RSA, with the aims of identifying, characterising and prioritising the sewerage reticulation issues requiring attention, and developing strategic guidelines for dealing with these. The findings of this project will form the framework for and lead to a future roll-out of focused research projects dealing with specific topics.

Estimated cost: R400 000
Expected term: 2006-2007

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 1: Quantification of water use and waste production

A first-order inventory of water use and waste production by the South African industrial, mining and power generation sectors
Arcus Gibb
No 1547

The aim with this project is to compile a first-order inventory of the amount of water used and waste produced by the South African industrial, mining and power generation sectors, and to assess the impact these have on water quality. Information in this regard is required to judge whether the present investment in research has the right mix and to provide strategic direction to research initiatives. The investigation will make optimal use of existing information such as the NATSURV investigation that provides a benchmark for water use and waste production by major South African industries, the COMRO report on water use by gold-mines, a WRC report on water use by coal-mines, a CSIR report on national waste production and DWAF's Water Resource Strategy on water requirements by different sectors. The available information will where necessary be supplemented by targeted field investigations and compiled into a consolidated overview that presents the total picture. The data on water use and waste production will furthermore be interpreted for the effect they can be expected to have on receiving water quality. In order to ensure credibility of the findings, they will be verified through a workshop with practitioners.

Estimated cost: R600 000
Expected term: 2004-2005

A first order assessment of the quantity and quality of non-point sources of pollution associated with the industrial, mining and power generation sectors
Pulles, Howard and de Lange Inc
No 1627

It is increasingly recognised that non-point source (NPS) pollution plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore, increasingly accepted that it is not feasible to properly manage water quality without addressing the contribution from non-point sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. This project will determine at a scoping level, the quantity and quality of NPS pollution that originate from the mining, industrial and power generation sectors. This information will inter alia be used at a strategic level, to determine whether the present investment in research in this KSA and more specifically the thrust on industrial and mine-water management, reflect the need in this regard.

Estimated cost: R1 000 000
Expected term: 2005-2007

Programme 2: Regulatory mechanisms to improve industrial and mine-water management

Valuing water for South African industries: A production function approach
Environmentek, CSIR
No 1366

The industrial sector in South Africa is one of the fastest growing sectors and relies to varying degrees (ranging from wet to essentially dry industries) on water resources as an input to many production processes. Industrial water use currently comprises about 10% of the total water use in South Africa (WSAM 2000) and is therefore a significant water-using (and effluent-generating) sector. Very little is, however, currently known about the responsiveness to water pricing within the industrial sector in South Africa, probably because of historically low pricing structures and the perception that industrial water use is better suited to engineering rather than economic analysis. International literature offers mixed results, with industrial price elasticities ranging from very inelastic to more elastic. In the context of the National Water Act and its emphasis on economic pricing, and the significance of industrial water use in South Africa, it is necessary to provide econometric tools to decision makers. The project aims to quantify and characterise the role that water plays in various local industries and their responsiveness to price changes; and to develop a set of indicators and judgement criteria for policy makers, decision takers and other stakeholders to use economic analysis for appropriate water resource management.

The project's overall aim is to determine the marginal value of industrial water in South Africa, in keeping with the NWA's objectives to price water correctly. The specific sub-goals are listed below:

- To assess the role that industries play in the overall water demand for South Africa, and to determine which industries are the most water-intensive and which industries are relatively water 'dry'
- To determine price elasticities of demand for water for the respective industrial sectors within South Africa, and develop a set of indicators that can be used in existing models or assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge.

Estimated cost: R549 600
Expected term: 2002-2005

Geochemical sampling and analyses for environmental risk assessments using the Wits Basin as a case study
Pulles, Howard and de Lange Inc
No 1624

Each environmental risk assessment (ERA) study is faced with questions regarding the location, number, size and type of samples that need to be collected for a proper assessment. Answers to these questions are partially dependent on the predictions that need to be made, the available material and costs. This project will establish a methodology to guide users of an ERA process to quantify the uncertainty associated with predicted mine drainage quality as a function of sample representivity. Existing mineralogical and geochemical data for the Wits Basin, that are available from previous studies, will be used to demonstrate the application of the methodology that will be developed.

Estimated cost: R 562 000
Expected term: 2005-2008

Programme 3: Minimising the impact of waste on the water environment

Arsenate resistance in microbial communities developing in maturing FA-AMD solids
University of the Western Cape, Department of Microbiology
No 1655

The WRC and the mining industry are investigating the use of fly ash to neutralise AMD and produce useful by-products, such as zeolites. The use of fly ash AMD substrate as backfill in underground mines is under consideration. However, the potential mobilisation of undesirable metals and other contaminants by microbial activity, give rise to concern. Recently completed Project **No 1549** found that while microbial populations are slow to develop in the substrates, they are readily sustained once they are introduced. This project will continue with the current research and study specifically arsenate reactions, as proxy for other contaminants that are subject to redox reactions.

Estimated cost: R220 000
Expected term: 2006-2008

Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments
Pulles, Howard and de Lange Inc
No 1659

Defunct gold mines on the East and West Rand are rapidly filling up with contaminated water that will decant into the Vaal River system. Previous studies focused on either reducing inflow to the underground or on diverting decant water to preferred locations for treatment. This project will identify locations within the flooded basin where water quality is relatively good and which are also major recharge points (and therefore decant drivers). It is proposed to dewater the basins from these points. If found feasible, the extraction of water from such points, would serve as a source of water for Gauteng and at the same time reduce the magnitude of decant.

Estimated cost: R501 300
Expected term: 2006-2008

Programme 4: Minimising waste production

Promotion of biodegradable chemicals in the textile industry using the score system: Phase 1 – Pilot study
School of Chemical Engineering, University of KwaZulu-Natal
No 1363

The score system is a management tool, developed in Europe, for monitoring the environmental pollution potential of a company based on the characteristics of the chemicals used and which could report to the effluent. The parameters assessed are the amount of substance used and its biodegradability, bio-accumulability and toxicity, each of which is given a logarithmic score of between 1 (low environmental burden) and 4 (substantial negative environmental impact) to derive a composite 'score'. In this project the system is being tested for its applicability to the RSA, using textile companies as the initial pilot study. The objective is to reduce the environmental impact of a company, as measured by its 'score', by minimisation of the chemicals used and/or their substitution in favour of less environmentally aggressive choices. If successful, the concept could be advanced for other industrial sectors as a generic environmental management protocol.

Estimated cost: R700 000
Expected term: 2002-2005

The introduction of cleaner production technologies in the mining industry
Digby Wells & Associates
No 1553

While the mining industry has played a major role in the development of South Africa (and is still continuing to do so) it has also been identified as the largest producer of waste and as a major contributor to water quality degradation in many of our important catchments. It is recognised that the long-term solution to waste management is to minimise waste production and introduce cleaner production technologies. An analysis of the WRC's past and present project portfolio indicated that most of the research effort to address water and waste management in the mining industry was devoted to minimising the impact of waste on the environment, to improve our ability to predict and quantify effects and to develop technologies to treat polluted waters. No projects devoted specifically to waste minimisation and cleaner production technologies were undertaken. Although cleaner production is an essential backdrop against which to do environmental management and the mining industry has launched initiatives such as the mining, minerals and sustainable development project, it does not appear as if the industry has embraced cleaner production, as yet. This project is aimed at introducing cleaner production to the mining industry and entrench its concepts where it is already being practiced. For this purpose multi-facetted initiatives will be undertaken to raise the awareness of the mining industry concerning the benefits and need for adopting cleaner production approaches. The project will start by assessing the level of awareness in the industry and identifying threats that could be alleviated by cleaner production technologies. Opportunities will be created to implement these and establish cleaner production forums (waste minimiation clubs) so that success stories can be generated which, in turn, can be used in an awareness campaign.

Estimated cost: R3 295 000
Expected term: 2004-2007

Cleaner production evaluation system and optimisation for metal finishing
Durban Institute of Technology
No 1626

The metal finishing industry is notorious for its polluting activities. Cleaner production audits to bench-mark a company's operations and identify room for improvement, require a level of detailed information that is normally not recorded by smaller companies. This project aims to develop a tool that can be used to readily conduct a systematic environmental evaluation of electroplating plants and which will provide a comprehensive audit, with limited data, in a consistent way.

Estimated cost: R492 000
Expected term: 2005-2007

An investigation of innovative approaches to brine handling
Proxa
No 1669

The problems associated with the management of inorganic waste products, (sludges and brines) that are being produced as a result of water treatment and recycling, present a major stumbling block to improved wastewater management. Available technologies are either prohibitively expensive or unsatisfactory because of the long-term liabilities and associated risks to water resources. This project will develop management solutions appropriate for the South African situation by assessing the current situation, establishing the present state of the art, developing a fundamental understanding of brine chemistry and the identification and proof of concept testing of promising innovative solutions. Promising solutions, which pass the proof of concept test, will be further evaluated in follow-on projects.

Estimated cost: R1 290 000
Expected term: 2006-2008

A pilot study into upstream cleaner production technologies for the petroleum refining industry to meet the requirements of the waste discharge charge system (WDCS)
Process Optimisation and Resource Management
No 1673

The main objectives of the Waste Discharge Charge System (WDCS), imminently due for implementation by DWAF, are to reduce water pollution by encouraging efficient resource utilisation (incentive objective), recovering the costs of activities aimed at pollution abatement and damage caused by pollution (financial objective), discouraging excessive pollution (deterrent objective) and promoting sustainable water use (social objective). This project aims to develop an understanding of the treatment processes, applicable to various industries, which could be used to meet the requirements of the WDCS. The project will use a petroleum refinery as a case study to investigate the financial impact of the WDCS on industry and to investigate source-reduction cleaner-production (upstream) options as opposed to an end-of-pipe treatment approach, exploiting a current real-life opportunity where these approaches to pollution prevention can be quantitatively compared. The specific aims of the project are to develop a prioritised list of upstream treatment technologies for the petroleum refining

industry, and to quantify the financial implications to the petroleum refining industry of meeting the WDCS requirements.

Estimated cost: R229 200
Expected term: 2006-2008

Programme 5: Improved ability to predict and quantify effects

Evaluation and validation of geochemical prediction techniques for underground coal mines in the Witbank/Highveld region
Pulles, Howard and de Lange Inc
No 1249

The Witbank/Highveld coal field in Mpumalanga is the most important coal mining area in South Africa. While this coal field makes a significant contribution to the economic development of the country it is also the source of potentially the most serious water quality problem facing the region over the longer term. There is thus an urgent need to develop and test tools with which to predict the progression of acid mine drainage (AMD) over time, and to develop, test and apply management options that will alleviate the situation. This project, together with **Project Nos 1263** and **1264** will investigate the management of groundwater flow in collieries at various stages of closure with an aim to minimise the salt load emanating from them, evaluate alternative geochemical prediction techniques to use in the longer term, comparison of alternative management options, and the mapping of modal proportions of primary and secondary minerals. The contribution of this project will be to evaluate alternative geochemical prediction techniques for the prediction of water quality at underground coal mines, based on on-site investigations and predictions, and to develop the ability to provide a long-term prediction of water quality and the effect of alternative management strategies on this water quality.

Estimated cost: R1 416 100
Expected term: 2001-2003

Development of water balances for operational and post-closure situations for gold-mine residue deposits to be used as input to pollution prediction studies for such facilities
Pulles Howard and de Lange Inc
No 1460

The area covered by slimes dams is in the order of 400 km². Previous research has indicated a varying but significant potential for pollution underneath these dumps. The overall water balance of a dump is the main driving force behind this pollution. The water balance of tailings and rock dump facilities is not very well understood at present, both locally and internationally. This seriously limits our ability to make reliable predictions of post-closure pollution potential and to properly evaluate environmental management/rehabilitation strategies. This project aims to develop a procedure and methodology that can be used in developing water balances for gold-mine waste residue deposits. These water balances play a critical role in geochemical modelling of such deposits.

Estimated cost: R913 500
Expected term: 2003-2006

Study of the kinetic development of oxidation zones of tailings dams with specific reference to the Witwatersrand gold mine tailings dams
Pulles Howard and de Lange Inc
No 1554

(**Project No 1347**) aimed to determine and predict the depth and rate of weathering on gold tailings dams, and to develop rapid procedures to assess the risk for a specific tailings dam to produce AMD. This project will complement and extend the earlier investigation by building on its findings and extending them. The large-scale reclamation of dams, ranging from 10 to 100 years in age, provides a perfect opportunity to study tailings dam profiles and characterise their oxidation profiles. The project aims to advance our knowledge and ability to practically implement improved prediction capacity in the following areas:

- Establishment of validated kinetic variation of oxidation zones
- Increasing the accuracy of predicting the depth of oxidation zones
- Increasing the accuracy of predicting the phreatic surface
- Applications to any other similar environment, e.g. platinum group metals (PGM) and copper mine tailings.

Estimated cost: R360 000
Expected term: 2004-2005

Prediction of how different management options will affect drainage water quality and quantity in the Mpumalanga coal mines up to 2040
Golder Associates Africa (Pty) Ltd
No 1628

Coal mining in the Mpumalanga coal-field is a mature activity. Many mines have already closed and several more are heading for closure during the next 20 years. The AMD that emanates from closed and operating mines have a huge impact on the water quality of the area. Because of the lag effect, it is likely that this impact will increase in future. Several investigations over the last decade were aimed at obtaining an improved understanding of how different management options would affect the quantity and quality of AMD emanating from mines. This project will build on mainly available information to predict how the quantity and quality of acid mine drainage emanating from coal mines in the Mpumalanga Highveld will change over the next 40 years for a range of different management scenarios.

Estimated cost: R1 500 000
Expected term: 2005-2007

Origin of sodium and its applications to water quality prediction in the South African coal mine environment
University of Fort Hare, Department of Geology
No 1663

In addition to experiencing an AMD problem, the Mpumalanga coal fields also experience an increase in the sodium concentration of mine drainage from north to south. This phenomenon adds to the unacceptability of mine drainage. This project aims at finding an explanation for the phenomenon and, to a lesser degree, to propose treatment, prevention and management strategies to address the problem.

Estimated cost: R337 600
Expected term: 2006-2008

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS
University of Venda, Department of Microbiology
No 1653

The spread of HIV, which causes AIDS, is taking place at an alarming rate. The situation for HIV/AIDS infected individuals is exacerbated by the fact that a large proportion has no access to safe water or adequate sanitation. The lack of safe water compounds health risks to HIV/AIDS individuals leading to increased vulnerability, decline in productivity and income and consequently a general decline in their socio-economic status. HIV/AIDS is not a water-borne disease therefore there appears to be little relation to each other but a poor microbiological quality of their drinking water could have detrimental impacts on the health of HIV/AIDS infected individuals. This project aims to do a health impact assessment study based on the microbiological quality of drinking water used by rural households that have at least one HIV/AIDS infected individual. The presence of selected pathogenic and opportunistic bacteria and viruses in drinking water with those present in stool samples of both people living with HIV/AIDS and healthy individuals will be correlated to identify the relationship between point-of use drinking water quality and health indicators (such as diarrhoeal morbidity and mortality).

Estimated cost: R800 360
Expected term: 2006-2008

A guideline document for the implementation of sanitation, health and hygiene education (HHE) programmes in informal settlements
Nemai Consulting
No 1656

The provision of a guideline/tool for promotion of HHE in informal areas is a gap identified by current research. The attention and priority given to 'informal settlements' is generally lacking with the notion that people do not belong there. Also, current planning approaches neglect the situation and challenges in these settlements resulting in a burden of poverty and diseases. This has a negative impact on the wider society and approaches need to be introduced to ensure that informal settlement are afforded the knowledge of basic health issues which affect their environment.

Currently the services of environmental health workers are usually not directed at sanitation related health and hygiene promotion. Very few WSAs have a sanitation department/unit that deals with low-cost sanitation. Even fewer WSAs have sanitation managers. Where such sanitation departments/units exist, and there are sanitation managers, there are limited numbers of sanitation services managers who understand the specific requirements (and institutional demands) posed by alternative sanitation delivery. Ultimately, where there are such units, and they are managed, they do not have the human resources to address the technical, DRA and H&H requirements related to the provision of non-waterborne sanitation.

This study is a small step in assisting water services to engage with informal areas in the promotion of HHE and sanitation. The tool to be developed is aimed at empowering them on how to address the situation and provide a sustainable service. The current typhoid outbreak is a good example of the lack of education in informal areas, alleviated by poor management of water and sanitation services.

Estimated cost: R570 000
Expected term: 2006-2008

Develop the guideline: Management of Microbial Water-Borne Diseases Vol 5: What We and Our Children Ought to Know
University of Venda
No 1672

This volume will include home hygiene and a link to sanitation, different water sources and handling of water from the sources. Disinfection and its side effects, the boiling of water and when not to boil, danger of burn wounds, etc. The origin and transmission of diarrhoeal diseases, prevention and care, will be included, as well as emergency treatment of diarrhoeal cases and special care of the immuno-compromised. Handling of containers in households, storage, contamination, etc. will also be included.

All of these need to be described in a simple demonstrative way taking into account the already available posters, pamphlets and reports available at the WRC, DoH, DWAF and other such documents developed by water suppliers, NGO, DoE (school curricula), etc. to get the most suitable and effective method of transferring the message to the community. Cultural differences and preferences have to be taken into consideration.

Estimated cost: R400 000
Expected term: 2006-2008

Programme 2: Peri-urban sanitation research

Effective demand for alternative sanitation options in peri-urban settlements
Sigodi Marah Martin (Pty) Ltd
No 1664

This project offers an innovative approach of using tried and tested approaches of contingent evaluation approaches that aim to improve the science and understanding of sanitation demand by exploring and applying existing and tried and tested approaches to sanitation. Through this process, it aims to provide knowledge and information as to what people in low-income areas are willing to pay for sanitation. This kind of knowledge and information is lacking. The lack of this information results in unpopular decisions and programmes being made on behalf of recipients. Further, this information could be relevant to informing policy at a national level and local level towards better programmes that are sustainable.

Estimated cost: R710 000
Expected term: 2006-2008

Programme 3: Institutional and management aspects of sanitation service delivery

Financial sustainability of sanitation services
Partners in Development
No 1632

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices:

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall cost strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best-practice case studies
- Exploration of credit finance options for household sanitation improvement programmes.

Estimated cost: R600 000
Expected term: 2005-2007

Programme 4: Technical sustainability of sanitation services

Sustainable options for community level management of grey-water in settlements without on-site waterborne sanitation
University of Cape Town, Department of Civil Engineering
No 1654

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects, which influences the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local

communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be possible for extension to the rest of South Africa. This will be supported by preparation of education material for community level training concerning grey-water management options and techniques.

Estimated cost: R750 000
Expected term: 2006-2009

NEW

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost recovery in water services

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa
Palmer Dev Group/Cape Town Office
No 1713

A study conducted in Johannesburg in 2005 indicated that consumer units are larger in poorer areas. This is due in part to the fact that consumer units frequently comprise more than 1 household - the study indicated that in the areas surveyed consumer units were made up of 2 to 3 households on average. Most of the research on larger consumer units in urban areas has focused on units that include backyard shacks. There has been little focus on the broader group of large consumer units, of which units with backyard shacks are just one component. The phenomenon of large consumer units poses a problem with regard to the affordability of water services. The research will investigate the phenomenon of large consumer units in poorer urban areas. The study will focus on the structure of large consumer units in poorer urban areas, and the extent to which these consumer units consist of multiple households (possibly living in backyard shacks, but also possibly sharing a dwelling). In particular, the study will examine how the members of large consumer units access water services, and how they pay for these services. It is anticipated that gathering this information will assist municipalities to refine their strategies around delivering free basic water services and inform the structure of water and sanitation tariffs, thus improving cost recovery for water services.

Estimated cost: R390 550
Expected term: 2007-2008

Programme 3: Innovative management arrangements – Rural water supply

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities
Cape Peninsula University of Technology
No 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services. Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of the operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324
Expected term: 2007-2009

Programme 4: Regulation in the water services sector

Development of a framework and model to regulate the competencies and training of managers and technicians in the provision of water services
University of the Witwatersrand
No 1715

Currently there is a lack of an understanding of the appropriate generic approaches to qualifications, competence and skills in a technical sector such as water services.

Reviewing the water services and related (municipal, health, construction, electricity) legislation and regulations, it is evident that there is a huge gap in identifying current institutional arrangements for regulating qualifications, competences, training and development. Furthermore, this is compounded by a lack of a conceptual framework and model for the qualifications competences and skills required for effective provision of water services.

This study aims, on the basis of the engagement with stakeholders, to develop an appropriate framework for competences and skills in water services. It will develop an understanding of the specific qualifications, competences and skills that are required for the effective provision of water services in South Africa. It will also clarify options and propose mechanisms that can be used to ensure that necessary qualifications, competences and skills are available to all water services authorities and providers.

Estimated cost: R350 000
Expected term: 2007-2008

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Development of a durable and reliable wave-energy reverse osmosis system
The Impact Free Water Group
No 1716

Small, rural communities living at or close to the sea along the coastline of the country rarely have a good and reliable supply of potable water – nor do they generally have electricity. The project aims to further develop an innovative reverse osmosis system which utilises ocean wave power in order to produce the elevated pressures required in the desalination of sea water to potable standards. A few prototypes will be constructed to evaluate the effect of various wave parameters on the system performance and improve the system into a practical, working technology.

Estimated cost: R650 000
Expected term: 2007-2010

Two-stage reclamation of filter backwash water at treatment plants using source water with high algal content
University of Pretoria
No 1717

Backwash water is wasted rather than sent back to headwaters due to concerns over the accumulation of organic compounds released from algae and cyanobacteria, a source of disinfection by-products (DBPs) during chlorination. Additionally, backwash water has been demonstrated to be difficult to settle. In this project, a treatment technology for efficient solids separation and elimination of organic

compounds before recycling of backwash water will be investigated. A system based on advanced oxidation semiconductor photocatalysis in the fixed-phase will be developed and will be tested against a method using ultrasonic cavitation to degrade the organic compounds in the backwash. Current cost-effective membrane separation techniques will be used to complement the photocatalytic or ultrasonication methods.

Estimated cost: R830 000
Expected term: 2007-2009

Programme 2: Water treatment for rural communities

A management information tool for the efficient operation and maintenance of small water treatment plants
Swartz Eng
No 1718

The performance of small (and also some medium sized) water treatment plants in terms of the provision of a potable standard of drinking water to the end consumer is suspect. Studies have shown that the overall management of water provision is not as effective as it should be – with particular reference to plant operation and maintenance. One of these reasons is the lack of an adequate and efficient management information system. The project, therefore, aims to develop and compile a practical and user-friendly management information tool to facilitate the efficient operation and maintenance of small water treatment plants under the jurisdiction of a water services authority.

Estimated cost: R800 000
Expected term: 2007-2009

Programme 3: Drinking water quality

Investigation of the distribution and diversity of South African toxic freshwater cyanobacteria with special reference to analysis of the neurotoxin BMAA and molecular genetic methods for microcystin screening
NMMU
No 1719

There is a lack of standardised methods and facilities for analysis of toxic cyanobacteria and quantification of cyanobacterial toxins in South Africa. Commercial primer sets for such screening will soon be available, but their suitability or applicability to South African isolates is totally unknown. No comprehensive analysis of wild strains has been attempted using any molecular technique. The application of appropriate techniques will yield information on the relationship between South African and other strains and information on the distribution and spread of strains within South Africa. Screening studies by various laboratories have indicated that all known species of cyanobacteria can produce BMAA. This has obvious implications for the human/health related chronic exposure to BMAA in water, where cyanobacterial aggressions occur. The aim of the study will therefore be to investigate the distribution and diversity of South African freshwater toxic cyanobacteria from a phylogenetic/phylogeographic perspective with specific reference to toxicity for known toxins and including the establishment of analytical procedures for the novel toxin BMAA.

Estimated cost: R1 000 000
Expected term: 2007-2009

Situation and gap analysis of water quality testing in South Africa
Jeffares & Green
No 1720

The irregularities and occasional health risks currently experienced in water quality throughout South Africa highlights the urgent need for the introduction of an accepted and practical water quality testing standard to be employed by all laboratories in South Africa and enforced at national regulatory level. In order to produce such a standard, it is imperative that a thorough investigation be carried out into existing conditions, problems and capacities of all water testing laboratories in South Africa. The assessment of the current status of testing laboratories will therefore play an important role in establishing what action needs to be taken to ensure acceptable water quality throughout South Africa. The overall aim of the project will be to develop a strategy for a national programme that will address the needs of the water quality assessment in South Africa.

Expected cost: R800 000
Estimated term: 2007-2009

Programme 4: Water distribution and distribution systems

Inverse transients to determine deficiencies in pipelines
University of Pretoria
No 1721

A major shortcoming in the optimal utilisation of water distribution systems is the uncertainty about the physical status and the identification of operational deficiencies. In a WRC study (*Report No 1177/1/04*) the influence of localised air pockets on the hydraulic capacity of pipelines was shown. Another major problem that negates the optimal distribution of water is the presence of unidentified leakages in the systems. Inverse transients can be used to determine the location and magnitude of leaks and air pockets. The technique was already tested in laboratory conditions, indicating the advantage of this technique. The procedure could be applied without isolating the section to be investigated (no interruption of the service). The objective now is to test and develop this further and provide assistance in the implementation of this procedure. The value of the development of this technique is that a non-destructive, non-intrusive and un-intermittent procedure will be available to investigate the status of water distribution systems.

Expected cost: R530 000
Estimated term: 2007-2010

Guidelines on how to determine and reduce apparent losses
Conward Consulting
No 1722

Non-revenue demand is one of the key performance criteria of water services providers (WSP) in South Africa. The current level of non-revenue demand is estimated at more than 30% of the total water supplied. Non-revenue demand can be divided into two main categories: real losses and apparent losses. Before WSP can begin to address non-revenue demand, they need to understand the extent of real losses versus apparent losses. Currently, there is no common approach or guidelines on how to estimate apparent losses and this is widely considered as one of the main constraints in dealing with the overall issue of non-revenue demand. The development of guidelines on how to accurately determine apparent losses will provide a key breakthrough for WSP to deal with non-revenue demand and for the regulator in setting bench-marks and targets.

Expected cost: R400 000
Estimated term: 2007-2009

THRUST 3: WASTEWATER AND EFFLUENT TREATMENT REUSE TECHNOLOGY

Programme 2: Sludge characterisation, treatment, utilisation and disposal

Guidelines for the utilisation and disposal of water treatment residues
Golder Associates Africa (Pty) Ltd
No 1723

WRC **Project No 1148** found that the disposal of water treatment residues (WTR) to land could have positive effects. No local guidelines for land disposal exist at present. In order to determine what information is still required to develop such guidelines, a follow-on **Project No 1601** produced a scoping report on the development of guidelines for the land disposal of WTR. Although a number of knowledge gaps remain, this new study will develop guidelines based on the best current local and international information. The objective is to revisit these guidelines after 5 to 10 years of application and include actual field data and

experience gained during this period. A national survey will determine the variation in the characteristics of different WTRs. The previous research and survey data will be used to develop guidelines that describe the requirements for the land disposal and agricultural use of WTR. A stakeholder consultation and scientific peer review process is planned to gain broad acceptance for the guidelines.

Estimated cost: R746 820
Expected term: 2007-2009

Sustainable and beneficial use of biosolids land application strategies: Quantifying nitrogen and phosphorus plant-soil mass balances
University of Pretoria
No 1724

The recently published *Guidelines for the Utilisation and Disposal of Wastewater Sludge* promotes the sustainable use of sewage sludge as a soil ameliorant and source of nutrients for crop production. However, limited research on the topic has been conducted under local conditions. This study will investigate aspects of the use of wastewater sludge on land, including high application rates. They will focus on N and P release from sludges and on soil-plant-water interactions with the released nutrients, in order to promote responsible sludge use and minimise groundwater pollution. Use will be made of laboratory, lysimeter and field experiments. Findings will be incorporated into a mechanistic daily time step nutrient and water balance model to improve the management of sludges and effluents.

Estimated cost: R1 150 000
Expected term: 2007-2010

Programme 3: Treatment and recovery of organics from agro-industrial processing

'Health for Purpose' in wetlands treating waste streams
University of Cape Town
No 1725

Wetlands used for the treatment of high COD and BOD effluents need to be managed to avoid imbalance and overload. The presence of key degrading organisms in a specific biodegradative community offers the potential to develop a 'fingerprinting' technology for identifying the presence and monitoring the 'health' of such a community. The study hypothesises that the impact of pollutant addition on natural microbial populations can be demonstrated by molecular methods to monitor the survival, and more importantly, the health of the microbial population responsible for the biodegradation of the impacting pollutant. The study aims to develop molecular fingerprints of microbial communities and key degradative enzymes involved in the degradation of specific pollutants; development methods to demonstrate microbial population changes resulting from the impact of polluting wastewater; and, investigate the effects of specific interventions on the 'health-for-purpose' of the wetland microbial population.

Estimated cost: R1 465 000
Expected term: 2007-2011

Beneficiation of agri-industry effluents
University of Cape Town
No 1726

This study focuses on extractive treatment of agro-industrial effluents, specifically effluents produced by the fruit and wine industries and the simultaneous recovery of high-value by-products. The study builds on research which focused on the characterisation of specific wastes with respect to potential economic value and separation and bioconversion technologies. The study aims to characterise the wastes from the fruit and wine industries; develop and customise new extraction processes to obtain antioxidants; investigate and optimise fermentation of residuals after extraction; and, investigate and determine the economic and commercial aspects. The outcome of this research potentially lends itself to a broad range of applications not yet developed in South Africa.

Estimated cost: R825 000
Expected term: 2007-2010

Programme 4: Treatment and recovery of inorganics in industrial and mining effluents

Novel technology for the recovery of water and solid salts from hypersaline brines: Eutectic freeze crystallisation
University of Cape Town
No 1727

With increasing use of recycling technology and water recovery by industry, there is an increase in the generation of inorganic brines and concentrates. This study will conduct a proof of concept study for SA conditions and brines on the novel technology of eutectic freeze crystallisation as a means to recover water and salts from hypersaline brines. This technology is reported to be significantly cheaper than the present bench-mark of evaporative crystallisation. The research team will cooperate with the Dutch developers of the technology.

Estimated cost: R793 305
Expected term: 2007-2010

Cellulose fermentation products as energy source for biological sulphate reduction
CSIR
No 1728

The CSIR developed an alternative biological sulphate removal process which uses the degradation products of plant biomass (grass cuttings) as the carbon source. The study showed that volatile fatty acids (VFAs) are produced which can subsequently be used as the carbon and energy source for the biological sulphate removal process which can take place in the same reactor. Micro-organisms which were sourced from rumen fluid and compost were used. This project builds on these results and aims to establish whether certain micro-organisms obtained from rumen fluid can adapt to converting plant biomass to VFA at ambient temperatures and determine whether the micro-organisms isolated from compost can be sustainably used in these systems over longer experimental periods.

Estimated cost: R350 000
Expected term: 2007-2008

Reactor design for metal precipitation in mine water treatment
University of Cape Town
No 1729

Regulatory restrictions make it increasingly difficult to dispose of metal-rich sludges. It is advantageous to have it concentrated in a relatively small volume. The trend is therefore to develop the means to produce separate metal-rich and metal-poor sludges. This study aims to optimise the metal precipitation component of the biological sulphate removal from acid mine drainage. It will focus on the sulphate reduction process in which metals are precipitated upstream of the sulphate reduction reactor.

Estimated cost: R197 300
Expected term: 2007-2008

Programme 5: Training in wastewater treatment plant operation

Field guide for inspections at waterworks
Golder Associates Africa (Pty) Ltd
No 1730

Currently, process controllers and inspectors do not have a reference guide which shows them exactly what to look out for at the various unit processes when undertaking an inspection. In this project a user-friendly checklist based inspection guide for water and wastewater treatment plants will be developed. The project will survey current processes, literature, methodologies and checklists related to inspections at water and wastewater treatment works based on the unit processes identified and consolidate the findings into user-friendly guides that

will contain checklists to identify potential problems based on categories such as technical, health, safety and environment and recommendation tables (i.e. possible solutions) for each unit process.

Estimated cost: R276 420
Expected term: 2007-2008

Programme 7: Sewerage reticulation

Stormwater ingress in South African sewer systems: Understanding the problem and dealing with it
Duzi-uMngeni Conservation Trust
No 1731

A cost-effective way to reduce the burden on the sewer system would be to reduce domestic stormwater ingress into the sewers. This study will investigate the extent to which stormwater ingress is overloading the sewage treatment plants in South Africa; investigate the causes of the stormwater ingress; identify legislation and local by-laws that can be used by municipal departments to prevent stormwater ingress; and, to develop and test a cost-effective education and inspection programme to reduce stormwater ingress to sewer systems using a case study. Using this case study, other municipalities could note the benefit and adopt similar approaches, if applicable.

Estimated cost: R334 250
Expected term: 2007-2009

Programme 9: Energy from waste

Energy from waste
University of Cape Town
No 1732

The energy shortages which are facing the country suggest a need to broaden the suite of energy supply options. During this study, trends and developments on the subject of energy from domestic and industrial wastewater and the residues will be reviewed and consolidated. It will provide a first order estimate of the quantity of domestic and industrial waste available and the potential contribution this can make to the national energy needs. It will document sustainable methods and technologies for generating energy from domestic and industrial wastewater. The project team will identify issues of concern, challenges, and research needs in this area which are relevant to South Africa. They will also highlight activities that are already taking place by other role players. This information will be used to develop guidelines for the approach to be adopted by WRC with other role players to address the issues/needs identified.

Estimated cost: R420 000
Expected term: 2007-2008

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 2: Regulatory mechanisms to improve industrial and mine-water management

Development of guidelines for urban metros to facilitate legal compliance with respect to industrial waste management
Nancy Oosthuizen Consulting
No 1733

eThekwini Metro has recognised that better waste management practices should be achieved as ineffective waste management practices are impacting negatively on cities' water resources. This case study aims to develop a set of easy-to-interpret, laymen's guidelines aimed at industry, ports, and intermediate waste contractors to achieve legal compliance related to responsibly managing wastes to achieve legal compliance. The products will not only benefit eThekwini, but all large metros and coastal cities as well.

Estimated cost: R350 000
Expected term: 2007-2008

Protocol for quantitative assessment of industrial effluents for discharge permitting
University of KwaZulu-Natal
No 1734

Local authorities manage industrial wastewater by:

- Using its wastewater treatment plants for remediation
- Issuing discharge permits with limits on discharge
- Charging a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system.

An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000
Expected term: 2007-2011

Programme 3: Minimising the impact of waste on the water environment

Refinement of the decision support system for metalliferous tailing disposal facilities
Golder Associates Africa (Pty) Ltd
No 1735

WRC Project No 1551 developed a first order decision support system (DSS) for the sustainable design, operation and closure of metalliferous tailings disposal facilities as part of a long-term programme to deal with these facilities on a sustainable basis. This follow-on project will refine the first-order DSS by developing guidance and support to demonstrate that the environmental impacts on the surface stability and water aspects are acceptable and to identify new and promising technologies and approaches.

Estimated cost: R2 200 000
Expected term: 2007-2009

Consideration of the impact of classification and landfilling of hazardous waste
CSIR
No 1736

The minimum requirements for general and hazardous waste have been in place for over a decade. A systematic assessment is needed to determine whether the desired groundwater protection has been achieved, particularly at sites that have received delisted wastes. The assumptions made in the delisting process (i.e. whether they are conservative or not) are tested against field data from operational landfills. Further, the impact of the disposal of hazardous waste on leachate quality and landfill processes is required. This study aims to begin the process by considering the impact of selected delisted hazardous or industrial waste on a selection of landfill sites. The study includes an assessment of leachate quality from a selection of general waste landfill sites that receive hazardous wastes compared to those that do not to validate the assumptions made in the delisting process and determining to what extent a selected hazardous waste type impacts on leachate quality.

Estimated cost: R800 000
Expected term: 2007-2009

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

A guideline document for emergency disinfection of drinking water
Tshwane Institute of Technology
No 1737

Untreated or inadequately treated water is still drawn directly from rivers, ponds, streams, and boreholes in some South African rural communities for domestic use. Various water-related infectious diseases including diarrhoea are often contracted, in some cases causing the death of the immuno-compromised individuals. In some instances, following natural disasters, a local authority may urge consumers at risk of contracting water-borne diseases to follow emergency disinfection measures. Messages and recommendations regarding the 'emerging' disinfection of untreated water do not take into account the variation in the quality of the source water. General guidance and recommendations on the use of a disinfectant or boiling of the water is usually given. In some instances this could add to the detrimental health effects of the water. The aim of this study is to consolidate available literature and information and develop a user-friendly guideline for emergency disinfection of untreated water.

Estimated cost: R600 000
Expected term: 2007-2009

Assessment of water, sanitation and hygiene services in relation to home/community-based care services for HIV/AIDS infected individuals in rural and peri-urban areas of South Africa
University of Venda
No 1738

This project will be done in collaboration with the Department of Health (DoH) and will provide an extension of the project funded by DoH. The HIV/AIDS epidemic has a devastating effect on the health and well being of the South African nation, but it also presents grave consequences for the socio-economic development of South Africa. Safe water and sanitation are basic needs and a human right, especially for people affected by HIV/AIDS as it will help them to live longer in good health and increase their dignity. This project will highlight the issues underlying the broad context for water supply, sanitation, and hygiene behaviour, and the need for systematic attention to these. This will be done in collaboration with DoH and MRC. The aim of this study is to provide insight into the extent to which water, sanitation and hygiene issues/practices are important and relevant for service providers and people living with HIV/AIDS, especially with regard to home/community based care.

Estimated cost: R500 000
Expected term: 2007-2009

Programme 3: Institutional and management aspects of sanitation service delivery

Examine the understanding and interpretation of sanitation policy and programmes
Hlathi Development Services
No 1741

South Africa is faced with a sanitation backlog that has to be redressed by 2010, and at present policy and strategy focus on delivery, rather than on sustainability of the sanitation services provided. The 2010 targets have been set by national government as being a basic level of sanitation because all effective sanitation must focus on people and not only the infrastructure. The primary focus of the policy is on the services provided by the water service authority, but also highlights that the end-user households share responsibility for good sanitation and effective sanitation practices. The water service authority is given the responsibility of monitoring and desludging on-site facilities, and/or relocation of on-site toilets when pits fill. There are, however, no existing policies or strategies that set out the detail of how this process is to be implemented. This implies that the operation and maintenance of rural sanitation systems are less than optimum, leaving the user with a level of service that is below the national average. This has numerous implications for the user and national government. Amongst the implications are health and cost factors.

Estimated cost: R400 000
Expected term: 2007-2009

Free basic sanitation – is it possible?
Hlathi Development Services
No 1742

The South African government has made a commitment to provide free basic water and sanitation services to the poor households. A review of progress in the implementation of the free basic water policy showed that the three poorest provinces are lagging behind with regard to the provision of free basic water (KZN, Limpopo and EC). More than 60% of the people without access to basic sanitation services are found in these three provinces. From this analysis, it is clear that the objective of providing free basic water and sanitation services to the poor households is proving to be difficult to achieve. The implementation of the free basic sanitation policy is more complex than water provision because of the different sanitation technologies that are used, e.g. for poor households with full waterborne sanitation, it is unclear whether the water for flushing or the cost of treating sewage should be subsidised. Should the municipalities be responsible for providing O&M for on-site sanitation? There is currently no policy for funding re-location of superstructure for full toilets or construction of new ones where relocation is not feasible. Thus, there is a need to identify successful and cost effective approaches of imple¬menting sanitation subsidies for sanitation infrastructure in order to achieve the 2010 sanitation target. Financial models and innovative strategies are required for assisting municipalities to provide sustainable free basic sanitation services to the poor household and to pay for ongoing O&M for these services. Good practice must be identified and scaled-up where possible.

Estimated cost: R700 000
Expected term: 2007-2009

What do we do to accelerate sanitation?
Hlathi Development Services
No 1743

The need to accelerate the provision of safe and hygienic sanitation to the approximately eight million South Africans who still lack it is an urgent priority. Safe sanitation and improved hygiene practices can save thousands of children's' lives every year. The dignity and quality of life of mainly poor people can be considerably enhanced. Government has accorded sanitation a very high priority and has committed itself to eliminating the backlog by 2010. However, at the current pace of delivery, this target will not be achieved. There is thus an urgent need to find ways to accelerate the pace of delivery, and to do so in such a way that the sustainability of the facilities provided and behaviour changes achieved are sustainable. The bottlenecks to faster delivery need to be identified and analysed, examples of how they have been successfully overcome documented, and tools and guidelines produced to help municipalities to achieve the required rate of sustainable service delivery. Ways also have to be found to reduce the cost of sanitation delivery to urban areas, and informal settlements in particular.

Estimated cost: R549 600
Expected term: 2007-2008

Programme 4: Technical sustainability of sanitation services

Development of a South African guide for the design and operation of waterborne sewerage systems
University of Pretoria
No 1744

Among the various sanitation options available, waterborne sanitation and its associated conventional sewerage system, or derivatives of such a system, still offers numerous advantages, especially in high-density settlements. A study of the methods used to treat the effluent arising from waterborne sewage has been completed and it is opportune to look at the reticulation systems themselves. With the growth in the economy, there will be growth in the residential and commercial developments in metros, cities and small towns. This will place greater demand on water services authorities to provide sanitation services With new emerging authorities, lack of capacity and competency at a local level, the situation can escalate and be costly to the country. Presently, there is no dedicated guide in South Africa which addresses the design and operation of waterborne sanitation systems. Much of the information is scattered in publications such as the Red Book (CSIR) and the good practical experience gained over the years within municipalities. Thus, the objectives of the study are to consolidate technical knowledge, information and advancements (local and international) on all waterborne sanitation systems.

Estimated cost: R615 000
Expected term: 2007-2009

Understanding the sludge accumulation in VIPs and other on-site sanitation systems and strategies to manage desludging in the future when pits are full
Partners in Development
No 1745

Current emphasis in sanitation rollout and the millions in investment have a bias towards putting in sanitation facilities in the form of dry VIP toilets. Though this is one of the essential components of sanitation delivery and the easier component, less emphasis is afforded to aspects such as ownership, participation, hygiene education and ongoing maintenance which are basically the more challenging and are the essential elements for sustainability in sanitation. It can be estimated that more than one million VIP systems will be built to meet backlogs. This is a huge investment by the Government; however, very little foresight and strategies have been developed how to manage these systems into the future. The research aims to tackle these questions of sustainability and, through the knowledge which is generated, make the sector better prepared to deal with the challenges. This study will develop an understanding of the sludge accumulation in VIPs and strategies to manage desludging in the future when pits are full.

Estimated cost: R1 600 000
Expected term: 2007-2010

Develop more robust and lighter VIP structures
University of Pretoria
No 1746

The premise of this study is based on the difficulties experienced in relocating VIP superstructures to new pits or to allow access for desludging. Thus, it would be ideal to develop a structure which can deal with these aspects where it can be sustainable, provide longer design life, be a durable, lightweight superstructure (with a total weight in the region of 500 kg) and which can be built and moved by rural households to new sites or to ease desludging. There are many advanced modern composites such as combinations of fibre reinforced high strength concrete and plastics, which, if made appropriate, could contribute to sustainable sanitation provision. Various combinations of composites can be developed in the most cost-efficient manner, which can be durable and affordable. The aim is thus to create designs which facilitate the reuse of superstructure building materials which, in turn, facilitate labour-intensive processes, as well as provide easier building techniques such that home-owners can rebuild their superstructures over a new pit without the services of a highly skilled builder.

Estimated cost: R1 100 000
Expected term: 2007-2010

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KSA 4: Water Utilisation in Agriculture

Dr Gerhard Backeberg | Director |
Water Research Commission

SCOPE

The strategic focus in this KSA , as described in previous years and found to be relevant by the External Institutional Review in July 2006, is on increasing the efficient use of water for the production of food, fibre, fuel-wood and timber; ensuring sustainable water resource use; reducing poverty and increasing the wealth of people dependent on water-based agriculture. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers is addressed through the creation and application of water-efficient production technologies, models and information systems within the following interrelated sub-sectors of agriculture, namely:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture.

The challenge for applied research and knowledge dissemination is to provide solutions to practical problems which are experienced in the process of utilisation, development and protection of water resources, thereby contributing to productivity growth in agriculture.

OBJECTIVES

The **primary objective** is to increase household food security and to improve the livelihoods of people on a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture.

The **secondary objectives** are to:

- Increase biological, technical and economic efficiency of water use
- Reduce poverty through water-based agricultural activities
- Increase the profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices.

Portfolios of current projects have been grouped into strategic thrusts and programmes which directly address the above-mentioned objectives. These will not be redirected or adjusted, after support was expressed by the WRC Board and the Minister of Water Affairs and Forestry in December 2006, and are summarised as follows:

THRUSTS AND PROGRAMMES

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

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 understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.

Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in the assessment of the fitness-for-use of water sources and identifying water related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

This thrust includes 2 programmes:

- Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture
- Fitness-for-use of water for crop production, livestock watering and aquaculture.

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuelwood and timber production.

This thrust includes 1 programme:

- Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations.

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Poverty, hunger and malnutrition amongst 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, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can be promoted further through participatory action research which improves knowledge, farming skills and leadership capabilities.

Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

This thrust includes 2 programmes:

- Sustainable water-based agricultural activities in rural communities
- Integrated water management for profitable farming systems.

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.

Agricultural decisions to use land and to conserve rainfall or to abstract water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

This thrust includes 2 programmes:

- Sustainable water resource use on irrigation schemes and within river catchments
- Impact assessment and environmental management of agricultural production.

RESEARCH PORTFOLIO FOR 2007/08

In this KSA a holistic approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction in rural areas and prevention of resource degradation. These efforts are aligned to the agricultural sector plan in South Africa and to the New Partnership for Africa's Development (NEPAD). Work will continue to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following themes of the research portfolio:

- Irrigation and water-use efficiency
- Fitness-for-use of water in agriculture
- Water-use efficiency in agro-forestry and woodlands
- Aquaculture in rural livelihoods
- Rainwater harvesting and conservation
- Adaptive research of technologies in rain-fed and irrigated agriculture
- Technology transfer of water management models
- Impact of land-use management on point and diffuse pollution in agriculture.

During the past 4 to 5 years a strategic shift has been made to achieve a balance between research projects in irrigated and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further to practical application of results with technology transfer projects. In future research, emphasis will be placed on the impact of aquaculture on water quality in dams; water use and biomass production of indigenous trees for carbon credits and employment creation; bio-physical and socio-economic feasibility of rainwater harvesting and conservation on freehold and communal cropland; optimisation of water use and integration of emerging farmers in food value chains; technology transfer for effective application of drip irrigation; vulnerability assessments in agriculture due to climate change; and uses of different sources of waste for food production.

BUDGET FOR RESEARCH PORTFOLIO IN 2007/08

The approved funding of the research portfolio of current projects and projects commencing in 2007/08 leads to a committed funding budget of R19 815 927. The focus of this portfolio will continue along the current trends.

CORE STRATEGY

Strategic context

The water resource base is of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people.

Water utilisation can best be quantified as rainfall-dependent, surface water- and groundwater-dependent use. Approximately 12 and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grasslands, woodlands and forests respectively. Rainwater runoff and deep percolation become available as surface water and groundwater of which approximately 62% is used for irrigation. It is therefore clear that the biggest share of water is used for both extensive and intensive production in agriculture.

In South Africa, at least 35% of the economically active population are directly or indirectly dependent on agriculture. This consists primarily of small-, medium- and large-scale enterprises, which provide employment opportunities for formal and casual labour. Furthermore, 42.7% of the population are rural survivalists with traditional agrarian lifestyles. Recent estimates also show that 48.5% of the population are living below the poverty line.

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low at between 2 to 3% of gross domestic product (GDP). The forward linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Agriculture is also a net exporter of food, contributing 10% of total exports of which 50% are processed products.

Critical issues in the forthcoming years and the next 2 decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing income levels of consumers. Expansion of agricultural production on land suitable for cultivation will be constrained by the availability of water. At the same time, there is a high ratio of people to cultivated land and a dependence on agriculture in rural areas, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background the strategic focus of water research in this KSA, which was found to be relevant by the External Institutional Review in July 2006, will continue to be on:

- Increasing the efficiency of water use for food, fibre, wood and timber production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Ensuring sustainable water resource use in rain-fed and irrigated areas (i.e. improving the knowledge of natural processes and people-induced impacts of resource use)
- Increasing the household food security and profitability of farming and thereby the livelihoods of people dependent on agriculture (i.e. improving the knowledge of management processes by people who are using water).

In drawing up plans to implement these strategies, cognisance has to be taken of the following factors:

Needs analysis

Previously identified needs, re-affirmed by recent reports and reviews, continue to give direction to applied research.

During 2000 the Presidential Imperative Programme on Integrated Sustainable Rural Development was announced. The goal of the programme is to promote development and improve the quality of life of marginalised groups and communities. The objectives are to alleviate poverty through enhanced production, productivity, creation of employment opportunities and a more equitable distribution of resources. Outputs which are envisaged include agricultural production systems and sustainable utilisation and management of natural resources and the environment.

At the end of 2001 the Strategic Plan for South African Agriculture was released by the National Department of Agriculture, AgriSA and the national African Farmers Union (NAFU). The strategic goal is to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural sector, contributing to a better life for all. This strategic goal is expected to guide all relevant partners in their quest to deliver and implement a range of programmes in accordance with basic premises of amongst others:

- Fair reward for effort, risk and innovation
- Security of tenure for present and future participants
- The sustainable use of natural and biological resources
- Sound research, science, knowledge and technology systems
- Market forces which direct business activity and resource allocation.

The outcomes which are envisaged to flow from successful implementation of programmes include:

- Increased creation of wealth in agriculture and rural areas
- Increased sustainable employment
- Increased income and foreign-exchange earnings
- Reduced poverty and inequalities in land and enterprise ownership
- Improved farming efficiency
- Improved national and household food security
- Increased investment in agricultural activities and rural areas.

One of the 3 core strategies which are discussed in the strategic sector plan for agriculture is sustainable resource management which also impacts on water systems. Central to this strategy is, inter alia, the promotion of sustainable use of soil and water through increased crop and livestock productivity and intensified farming systems, while farmer participation is a key success factor. Degradation of soil and water resources is considered to be a serious threat and therefore programmes must be designed to overcome the causes of degradation. Such soil and water conservation programmes will focus on areas where there is a reasonable chance of success as determined by, e.g. available technologies and access to markets, inputs and services.

On a regional level the Comprehensive Africa Agriculture Development Programme of NEPAD (2003), places the focus on land and water management as one of four pillars for priority investment. It is stated that 'water and its managed use has been an essential factor in raising the productivity of agriculture and ensuring predictability in outputs. Water is essential to bring forth the potential of the land and to enable varieties of both plants and animals to make full use of other yield-enhancing production factors. By raising productivity, water management (especially when combined with adequate soil husbandry) helps to ensure better production both for direct consumption and for commercial disposal, thereby enhancing the generation of economic surpluses which are necessary for uplifting rural communities.'

A call is made for increased investment in land and water and the point is made that 'protecting and improving water and the soil makes good business sense'. It is indicated 'that by enabling a rapid increase in production, irrigation can make food more readily available but that its impact on reducing hunger depends on appropriate arrangements for the poor to have access to irrigated land'. The further point is made that 'while increased irrigation is not a panacea for all agricultural ills, it nevertheless makes possible other opportunities for agricultural growth such as better husbandry of soils and resources in general, and makes more worthwhile the use of fertilisers, improved plant varieties and upgraded infrastructure.'

The Development Report by the DBSA (2005) found that 'the poverty problem remains a predominantly rural phenomenon'. Furthermore farming still provides 'a major source of income for many rural communities in South Africa' and therefore contributes to poverty alleviation. This role can be strengthened by investment in the drivers of agricultural development, namely human capital, biophysical capital, rural institutions and agricultural research. The conclusion is 'nonetheless, while agriculture plays a major role in poverty alleviation, promoting the growth of smallholder agriculture alone cannot solve the poverty problem in South Africa. More attention should also be given to the promotion of non-farm activities (e.g. agro-industries), particularly those that are linked to the smallholder agricultural sector. A strategy that strengthens farm/non-farm linkages is likely to yield better results with regard to employment and income generation.'

These needs as expressed by government and farmer representatives at national and regional levels are still relevant and as in previous years, highlight the key issues which must be addressed in the WRC research portfolio:

- Increased productivity of water for crop and livestock production
- Uplifting rural economies through commercial production

- Eradication of hunger and poverty
- Prevention of soil and water degradation
- Involvement of farmers in research.

Overview of technological trends

Efforts continue to stay at the forefront of technological developments and ensure application of existing technologies. This is achieved by purposefully leading the innovation cycle, which involves scientific research, practical application of inventions and exploitation of the commercial potential of the research output. A balance must therefore be found between research projects and technology transfer projects and also between research on appropriate technologies for irrigated and rain-fed agriculture.

With a growing demand for water in the domestic and industrial water-use sectors, the competition for water currently used for agricultural production will increase in future. Technologies, models and methods are available to improve the efficiency of irrigation water use in different stages of, e.g. canal and on-farm water distribution, field application and irrigation scheduling. With the demand for food also increasing in a globalised trade environment, agricultural production will have to be competitive in both local and overseas markets. While irrigated agriculture contributes 25 to 30% of gross production, technological and managerial innovations are required in all sub-sectors of agriculture to reduce costs and to increase income.

In particular, attention will have to be given to rain-fed agriculture and the existing technologies which have been developed for water harvesting in Sub-Saharan Africa. The impending challenge for research is therefore to adapt or develop and apply technologies which will enable water conservation in rain-fed agricultural production on dry-lands, grasslands and woodlands. In the case of irrigation, locally available technologies must be integrated and the financial benefit of efficient water use must be demonstrated over all stages of water distribution and application. Emphasis must be placed on making all technologies and models user-friendly. This requires attention to the specific needs of traditional subsistence farmers and modern commercial farmers.

The twofold effort to develop technologies for increased water-use efficiency in both rain-fed and irrigated agriculture, is also in support of global trends: As part of the water focus of the World Summit on Sustainable Development (WSSD), the recommended target is to increase water productivity in rain-fed and irrigated agriculture to enable achievement of food security for all people without increasing water use above levels for 2000. Furthermore, one of the four programmes identified within the NEPAD initiative, is to expand the extent and operation of integrated land and water management, with the main emphasis on the eradication of poverty in Africa. These trends have been reinforced by the Comprehensive Africa Agriculture Development Programme of NEPAD, published in July 2003.

Key stakeholders

This KSA strongly supports South African government strategies and initiatives where water and especially water utilisation for agriculture is of concern. Government departments, especially DWAF and the Department of Agriculture are the main key stakeholders. In addition, provincial departments of Agriculture, water user associations (WUAs), catchment management agencies (CMAs), cooperatives and agribusinesses, are all stakeholders with whom the WRC is engaging.

Key stakeholders and beneficiaries of this KSA remain as previously described. These are farmers who are represented by AgriSA and NAFU. Altogether these are an estimated 50 000 commercial farmers, 240 000 emergent farmers and 3 million subsistence farmers.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies must be designed to reach farmers and their representatives on a provincial and local level. The purpose is to obtain an accurate indication of practical problems which they are facing and what their assessment is of the priorities for research, technology transfer and extension.

Other 'players'

Other organisations providing services to water users in agriculture largely have remained the same as in previous years and are the provincial departments of Agriculture (PDAs), the national Department of Agriculture (DoA) through its Directorate: Water Use and Irrigation Development and DWAF through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC is an initiative by the DoA to give policy direction to development through integrated water management for agricultural use and DWAF is implementing a water conservation and demand management strategy in agriculture. An Interdepartmental Coordinating Committee on support for small-scale irrigation has also been formed, and as part of this action a task team is revising guidelines for project evaluation.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The NPA of Integrated Development is to undertake research which is designed to promote sustainable development in rural and urban areas. In addition various institutes of the Agricultural Research Council (ARC) obtain funding and undertake research on water-related subjects. Of particular relevance is water research in relation to soils and climate, engineering, field, horticultural and forage crops. At 8 universities across South Africa there are faculties or departments of agriculture, many of whom have in the past mainly relied on WRC funding to undertake water research.

Globally the International Water Management Institute (IWMI), as a member of the Consultative Group on International Agricultural Research, has a Sub-regional Office for Southern Africa in Pretoria. Since the establishment of the IWMI Africa Office, which is now based in Ghana, the WRC is serving on the IWMI-South Africa Consultative Committee with the main function to determine priorities for IWMI's work in this sub-region. The mission of IWMI is to improve water and land resources management for food, livelihoods and nature. Research is done under four revised themes:

- Understanding basin-scale water productivity
- Increasing water productivity for sustainable livelihoods
- Low-quality water, livelihoods, health and nutrition
- Water, sustainable agriculture and ecosystems.

The responsibilities of the South African Office include leadership and supervision of all work in Southern Africa; promoting strategic, applied research, capacity building and professional development; and collaboration with national, regional and international organisations.

STRATEGIC INITIATIVES

The KSA was involved in a number of key national, Africa-focused and international initiatives.

National initiatives

- The South African-French Network for Research in Water Science and Technology (SAFe Water) organised the inception workshop during April 2007. The theme of the workshop was 'New governance over water resources for sustainable rural development: Research on social, economic and institutional aspects'. This KSA was requested to make a presentation on the value and price of irrigation water.
- The annual general meeting and 2 ordinary meetings of the South African National Committee on Irrigation and Drainage (SANCID) were organised and chaired during April and October 2007. Following the second ordinary meeting, DWAF presented the annual SANCID lecture on the implementation of water conservation and demand management in agriculture.

- The regular meeting of the Network on Irrigation Research and Extension for Smallholder Agriculture (NIRESA) was held from 21 to 23 August 2007. A group of researchers and extensionists from universities, the Agricultural Research Council, provincial departments of Agriculture and private irrigation consulting companies participated in site visits and discussions on the Tugela Ferry irrigation scheme in KwaZulu-Natal Province. Presentations based on WRC projects were made by Prof Albert Modi of the University of KwaZulu-Natal and Richard Dladla of the Zakhe Training Institute.
- Also during August the KSA participated in the biennial congress of the South African Irrigation Institute (SAII). On invitation of the organisers two presentations were made on 'The use of poor quality water for irrigation – influence on the environment' and 'Managing the innovation process: from research to application'. At this occasion the SAII silver medal was awarded to the director of the KSA for his contribution to promote irrigation research in South Africa.
- The KSA negotiated and finalised a Collaboration Agreement with the DoA in July/August 2007 to secure leverage funding for research projects. The stakeholder map for KSA 4 has been completed.
- A consultancy project of the social, economic and environmental impact of infield rainwater harvesting and conservation in relation to rural livelihoods of households in villages at Thaba Nchu in the central Free State Province was initiated and completed by March 2008.
- Public appreciation of the research output of the KSA was achieved by 3 known non-solicited citations in the *Landbou Burger* of July 2007, *Afgriland* of Aug/September 2007 and *SA Irrigation* of October/November 2007.

African initiatives

As part of the African leadership, the WRC and the DoA hosted the ICID 2nd African Regional Conference from 6 to 9 November 2007 at Glenburn Lodge near Johannesburg. The WRC was represented on the Local Organising Committee and was responsible to convene the programme and finance sub-committees. Keynote speakers were invited from the World Bank, as well as Northern, Western, Eastern and Southern Africa. Sponsorship was obtained from the World Bank Institute, Food and Agriculture Organisation, ESKOM and Netafim. Altogether 120 delegates from 17 countries in Africa participated. The majority of papers presented by South African delegates were based on WRC research projects.

During the conference 2 sessions were hosted by the World Bank Institute to support cooperation between SARIA and ARID, regional associations of ICID in Southern and Western Africa respectively. SARIA is chaired by the WRC and during the first session an overview was given of the activities of SARIA. During the second session presentations were made on irrigation strategies by South Africa, Mali and Ghana. A regional workshop on rainwater harvesting and conservation by participants from South Africa, Kenya and Tanzania was planned for the week following the conference. This workshop had to be postponed to 2008 due to the withdrawal of two key presenters from Kenya and Tanzania.

International initiatives

The KSA represented South Africa at 3 international forums:

- The 58th International Executive Council (IEC) meeting of the International Commission on Irrigation and Drainage (ICID) was attended from 30 September to 6 October 2007 in Sacramento, California, USA
- The KSA presented 2 papers during a workshop of the ICID Working Group on Sustainable Use of Natural Resources for Crop Production; and during the USCID 4th International Conference on Irrigation and Drainage
- During the IEC meeting South Africa was awarded the ICID WatSave Innovative Water Management Award for a project on scheduling advice to smallholder cane growers, funded in partnership by the WRC and SASRI. The Best Paper Award 2007 was also presented to the Director of KSA 4 during the IEC meeting.

GROWING THE KNOWLEDGE BASE

Capacity building and competence development occur at the individual, organisational and community level:

Individual capacity development

Currently 112 students are receiving training as part of KSA 4 projects, of which 82 (73%) are from previously disadvantaged (PD) backgrounds. The total number of students as well as students from previously disadvantaged backgrounds has therefore practically remained constant compared to 2006/07. Thirty seven female students (21 Black and 16 White) or 33% of the total number are receiving project-related training.

The table below illustrates the number of post-graduate students who benefited from WRC-funded research in this KSA in 2007/08. This is in line with the set targets.

Organisation	Students from PD background	Total number of students
ARC	2	4
CSIR	11	12
University of Fort Hare	11	12
University of the Free State	8	12
University of KwaZulu-Natal	11	23
Sigma Beta	0	1
University of Pretoria	15	17
Rural Integrated Eng	7	7
SASRI	3	4
University of Stellenbosch	6	12
Tshwane University of Technology	7	7
Umhlaba Consulting	1	1
	82	**112**

Organisational capacity development

Nine current projects are being undertaken by private consultants. Four of these are emerging consultancy groups which have received research funding for the first time.

Community capacity development

Ongoing efforts are being made to undertake participatory action research projects where farmers benefit directly while the research is being done. At least 50% of the current and new projects involve some form of on-farm research in previously disadvantaged communities which enables project-related education and training of farmers. More concerted focus on this type of research is envisaged for new projects in 2008/09 and thereafter.

Leadership in water-centred knowledge comprised chairing national meetings of SANCID, NIRESA and SARIA; participating in national and international conferences and ICID working groups and presenting papers at one national and one international conference.

Effective **knowledge sharing** was achieved by organising 2 workshops during October 2007 and February 2008. A wide range of stakeholders from universities, science councils, government departments and private consulting groups were invited and participated. The subjects discussed during the workshop were as follows:

- Application of Remote Sensing to Estimate Water Use of Crops in Irrigated Agriculture, Stellenbosch, 25 October 2007
- Priorities for Follow-on Research on Water-use in Relation to Bio-mass of Indigenous Tree Species in Woodland, Forest and/or Plantation Conditions, Pietermaritzburg, 20 February 2008.

KSA 4 participated in one internal WRC Open Day in connection with, amongst others, irrigation on the Hartbeespoort Scheme as well as the WRC/DWAF Open Day.

Continued efforts have been made to improve the public understanding of water-related issues by means of popular articles in *The Water Wheel*, and providing brief summaries of recently published WRC reports in the magazine *Agri,* which is distributed nationally to farmers and agricultural interest groups. One new mechanism for knowledge dissemination was initiated with a series of articles on completed WRC projects published in the technical magazine *SA Irrigation*, starting in August/September 2007.

IMPLEMENTATION PLAN

Research portfolio for 2007/08

As in previous years, the **primary objective** is to increase household food security, improve livelihoods of people and to increase efficient growth and equitable distribution of wealth on a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture.

The **secondary objectives** are to:

- Increase biological, technical and economic efficiency of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices.

Expected outcomes

In KSA 4 a holistic approach is followed to enable people to utilise water in a sustainable way for food production. This contributes towards improved living conditions, maintenance of the productive capacity of water resources and availability of food and fibre products from rain-fed and irrigated cultivation. The participation of end-users in research projects and the application of knowledge generated through research are considered to be key success factors. This approach has been accepted by stakeholders but more time is required to demonstrate impact and therefore no change is considered at this stage.

A description of the research thrusts and programmes is given in **Table 1**.

RESEARCH PROJECTS FOR 2007/08

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

TABLE 1

Overview and description of thrusts and programmes

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture	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 understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.
Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture	Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations	In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Programme 1: Sustainable water-based agricultural activities in rural communities	Poverty, hunger and malnutrition amongst 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, rain-fed and irrigated crop production. 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.
Programme 2: Integrated water management for profitable farming systems	Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments	With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.
Programme 2: Impact assessment and environmental management of agricultural production	Agricultural decisions to use land and to conserve rainfall or to withdraw water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

COMPLETED

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

On-farm application of in-field water harvesting conservation techniques of small plots in the central region of SA
ISCW, ARC
No 1355

Water harvesting is the process of concentrating rainfall as runoff from a larger area for its productive use on a smaller area. A number of WRC projects on the In-field rainwater harvesting (IRWH) technique have demonstrated that rural communities can greatly benefit from this production practice. Intensive field experiments on clay and duplex soils, conducted over a period of 6 seasons, indicated that IRWH increased maize and sunflower yields by as much as 50%, compared to conventional production techniques. Research results over a number of years have indicated that the IRWH technique is sustainable in terms of increased agronomic productivity, reduction of risk, conservation of the natural resources base, social acceptability and economic feasibility. This technology transfer project was initially planned for implementation in 6 rural communities around the towns of Thaba Nchu and Botshabelo in the Free State Province over a 2-year period. The project had two main objectives:

- To exchange technology (IRWH) as effectively as possible with the owners of small areas of land and Department of Agriculture officials (especially those of the extension services)
- To assist and support the farmers and extension officers with the application of the IRWH technique.

The technology exchange process expanded rapidly resulting in many more households and communities than initially anticipated implementing the IRWH technique that the need to employ a proper exit strategy that ensured continued implementation of the technique by interested communities when the ARSC-ISCW team completed the project arose. Hence, a third objective was added to the initial two objectives, namely to develop guidelines for use by farmers and trainers practising IRWH and to develop an exit strategy. Observations of the expansion of the IRWH technique indicated that during the first growing season (2001/02) six households using backyards in four communities applied the technique. By 2002/03 this had increased to 108 households in six communities, and in 2003/04 the number had further increased to 400 households in 37 communities. The number of households in the communities that applied the IRWH technique during the 2003/04 season varied between one and 55 families per community. Before planting time for the 2004/05 season the number had further increased to more than 1 033 households in 42 communities and one trust farm. Training manuals were developed as part of this process and created a good platform for the compilation of training guidelines. The guidelines were tested and evaluated by the researchers, technical assistants, farmers and extension officers.

Cost: R1 487 000 (increased from R800 000)
Term: 2002-2006

Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research, Limpopo Province
Tshwane University of Technology
No 1464

The overall objective of the project was to develop and implement technologies and knowledge useful for farmers in order to improve rural livelihoods. Two types of research and development activities were conducted, namely initiatives aimed at understanding management practices and initiatives aimed at improving management activities. Methods used in data collection at Dzindi included:

- The use of Rapid Rural Appraisal (RRA) techniques
- Surveys involving probability sampling and structured interview schedules
- Experiments in the green house, on-station and on-farm
- Qualitative methods.

Methods of data collection at Khumbe and Rabali were largely limited to the use of RRA techniques.

The analysis of livelihood and farming of plot holder households revealed that for the purposes of developing best management practices, the 'one size fits all' perspective is not valid. At individual farm level best management practices need to be tailored to the objective of the farmer and the role of farming in the overall livelihood strategy of the household. The development of livelihood types, farming styles and the relationship between farming and overall livelihood were shown to be useful approaches to make sense of the diversity that was observed. The study of the social and institutional domains of Dzindi showed that there was considerable room to improve the management of shared resources. On smallholder canal irrigation schemes, the sharing of water and the maintenance of the irrigation infrastructure influence the availability of water for irrigation at the plots. Collaboration among farmers, or the lack thereof, also affects access to markets. However, the study found that state intervention (through the compulsory introduction of the co-operative model) in arenas where smallholders successfully operate their own organisations should either be avoided completely or be done in ways that allow smallholders sufficient time to internalise the new concepts and adapt them to suit their own circumstances. Land tenure and farmers' interpretation of the prevailing tenure system influence land exchange among farmers, which is important for farmers seeking to expand their operations. Collaboration among farmers is also important in terms of access to land preparation services. Research and development activities aimed at improving management practices focused on production aspects and included the integration of crop and animal production systems, improvement of the production of selected indigenous crops (African leafy vegetables) and the improvement of green maize production.

Cost: R1 200 000
Term: 2003-2007

Programme 2: Integrated water management for profitable farming systems

Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape
Department of Agricultural Economics, University of the Free State
No 1250

Risk management in agriculture has become an important part of the management function for primary producers, industry and government. Irrigated areas account for about 30% of agricultural production, so growth in irrigated output per unit of land and water is essential. Improved efficiency in agricultural water use is required both to maintain productivity growth and to allow reallocation of water from agriculture to urban and industrial use. The primary objective of this project was to quantify the impact of market risk on the efficient use of irrigation water and to determine the multiplier effects of irrigation accompanied by a shift in production patterns, with reference to the middle and lower Orange River, on the regional economy of the Northern Cape Province (NCP).

The typical farm-model scenarios showed that a decrease of 20% in the price of table grapes reduced the return on capital investment from 37.4% in the base to around 18.5% (reduction of more than 50% in net farm income). This represents a huge decrease in profitability. It is also important to note that a 20% reduction in the price of table grapes is an average reduction. There is substantial variation between the prices that farmers actually receive, since it will depend on the markets where the farmers sell their fruit and on the cost structure of the exporter. In this regard, farmers can reduce their risk. The results also clearly indicated that a more diverse farming

structure is a key strategy when it comes to reducing marketing risks. The results indicated that the optimum farm structure after a reduction in the price of table grapes is different to the observed farm structure. If farmers had better marketing information and the skills to interpret this information, they would have made different production decisions. The results for the two different macro-economic methodological approaches, i.e. the general equilibrium (CGE) model and the economic multiplies, are presented in the report. In the case of the CGE model a 20% decrease in the world fruit price was simulated. This shock was simulated to quantify its impact with specific reference to irrigation agriculture within the NCP. The results clearly show that the farm structure should have been more diversified. A more diversified farm structure enables farmers to absorb market failures more efficiently than with a specialised farm structure.

Cost: R1 333 729
Term: 2001-2008 (extended from 2005)

Technology transfer and integrated implementation of water management models in commercial farming
CPH Water
No 1481

This integrated transfer of technology project targeted the commercial irrigation sector in particular since, according to the *National Water Resources Strategy* (NWRS, first edition, 2004), this sector is responsible for over 62% of South Africa's total water use. The terms of reference required the research team to identify, negotiate with, and select 5 to 7 water user associations (WUAs) or irrigation boards (IBs) to participate in the technology transfer (TT) project. A key objective of the project was for the decision support models to be used sustainably after the completion of the project to increase efficiency of water use. As such, the potential participant WUAs/IBs were evaluated in terms of:

- Their user needs for the respective models
- The level of commitment shown
- The level of infrastructure of the respective schemes.

The participants were ranked in terms of these criteria, and short-listed. It is expected that the WUAs/IBs which were selected will act as centres of excellence, from which other WUAs/IBs can learn over time.
The models which were included in the TT exercise were ACRU, WAS, SAPWAT, SWB and RISKMAN. All models are driven by some form of input data, which is then transformed into information via computational processes through the models. A central approach of this integrated technology transfer project was to capture high quality data of the targeted participant WUAs and irrigation boards in a geographical information system (GIS). In the course of the implementation of the models, further developments were undertaken to improve the user friendliness. It was clear from earlier WRC projects that stakeholders showed a strong interest in GIS packages, largely due to the understanding that the use of GIS promotes for spatial and temporal information. This is due to the graphical (visual) nature of GIS which enables features to be viewed in a spatial context. In order to promote the buy-in from potential WUA and IB participants, a key feature of the project was the collection of data pertinent to the WUAs and IBs which would then be captured in a GIS. The data incorporated in the GIS could then be used (with other input data) to drive the models associated with the TT project. The current user needs for some of the models are very high, resulting in the models either being used now, or the intention to use the model in the near future (e.g. WAS & SAPWAT). For some of the other models the user need is growing, and is anticipated to grow significantly once the compulsory licensing process has been completed in many of the over-allocated catchments in the country. Models like SWB and RISKMAN will be very useful to test the hydro-economic impact of various water-use and land-use scenarios. Like-wise, the ACRU-MIKE BASIN model combination is well placed to assist water resource managers and stakeholders in evaluating water management scenarios.

Cost: R3 271 475 (increased from R2 250 000)
Term: 2004-2007

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Can effective management of riparian zone vegetation significantly reduce the cost of catchment management and enable greater productivity of land resources?
Environmentek, CSIR
No 1284

This research project investigated the links among vegetation, saturated zone dynamics, and runoff generation for the different classes of riparian zone. The impacts and effectiveness of the Working for Water (WfW) Programme in improving catchment water yield were quantified in a case study catchment in the Midlands area of KwaZulu-Natal. In the research the influence of stands of *Acacia mearnsii* (wattle trees) growing at different distances from a stream channel on soil water storage and streamflow were investigated before forest clearing, during clearing as well as after clearing. The research involved field measurements which were carried out in a closed catchment. The catchment was monitored as the riparian forests were cleared starting with the forests closest to the stream and data recording took place from January 2000 to October 2005.

The catchment data measurements involved automated continuous streamflow recording using a v-notch, rainfall gauging using tipping buckets as well as weather measurements from an installed Campbell Scientific Automatic Weather Station. Intensive soil-water monitoring instrumentation networks were established in the catchment. Evaporation monitoring in the catchment involved the use of several techniques including Bowen ratio energy balance, heat pulse velocity technique, and Large Aperture Scintillometer (LAS) instrument.

It was found that streamflow is only a small fraction of the annual rainfall, with the average rainfall: runoff ratio (Rr) = 3.4 %. Evaporation in the recolonised natural grassland in the cleared riparian strip ranged between 3 and 6.5 mm per day during the summer periods which was similar to that in the wattle forests during this period. However in winter, the evergreen wattle trees used much more water which dried the stream every year. In the forests, the evaporation was a very high percentage of the annual rainfall over the whole period with an average of 94.5%. In the 2002/2003 year this percentage was 106.9%, indicating that the evaporation exceeded rainfall. The impact of the clearing of the trees in this study was a 44% increase in streamflow.

Cost: R1 627 500 (increased from R727 500)
Term: 2001-2006 (extended from 2004)

CURRENT

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Quantification of the water use of four tree crops in the Lowveld of Mpumalanga
ARC
No 1046

Fruit tree species (high-value crops) have different water needs. These needs also change with growth stages – and are subject to climatic and edaphic factors. Where water becomes limiting, a decision tool becomes paramount so that farmers can decide beforehand which crops to produce. Such a tool also enables authorities to plan future expansions better, based on sound water budgeting. The aim of this research is to provide information on plant water use at various stages of growth. Water use by mango, avocado, litchi and macadamia nuts is measured.

Trees between one and twenty years old are used. This information will be used to develop guidelines for water budgeting within the fruit industry.

Estimated cost: R776 000
Expected term: 1999-2006

Standards and guidelines for improved efficiency of irrigation water use from dam-wall release to root zone application
ARC/IAE
No 1482

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The levels of efficiency of water use which are currently attained will be scrutinised and particular attention will have to be given to the management of water use. Broadly defined, management of water use starts at dam wall releases, through river or canal conveyance, on-farm storage and distribution, in-field application up to root zone storage. However, the problem is that at present there is no standardised terminology, comparable benchmarks or generally acceptable guidelines to improve water use and irrigation efficiency. These issues must be urgently addressed in order to provide consistent management advice and comply with the requirements of the National Water Act of 1998 regarding compulsory licensing and periodic review of licences. For the purpose of planning, design and operation of water supply systems, definitions of various efficiency terms need to be clearly stated, understood and accepted by all stakeholders. The site-specific criteria and tools which will be used to measure efficiency and practically achievable benchmarks need to be established. In order to achieve this, the proposed research project must be undertaken on a representative number of irrigation schemes which should include but are not limited to the following: Loskop: Tabina; Middle Letaba; Crocodile/Komati; Pongola; Makhatini; Gamtoos; Sundays; Orange-Riet; Vaalharts; Breede; Hex; Hartbeespoort.

Estimated cost: R4 500 000
Expected term: 2004-2009

Adapting the Wetting Front Detector to the needs of small-scale furrow irrigators and providing a basis for the interpretation of salt and nutrient measurements from the water sample
University Pretoria, Plant Production and Soil Science
No 1574

The Wetting Front Detector was developed by Australian scientist Richard Stirzaker following a number of years work at the Tompi Seleka College of Agriculture in the Limpopo Province. The WRC funded a project (WRC *Report No TT 230/04 Building Capacity in Irrigation Management with Wetting Front Detectors*) between June 2000 and December 2003 to continue the development of the Detector and introduce the technology to irrigation farmers in South Africa. Early results from field trials and feedback from farmers were sufficient to convince an irrigation agronomist from a South African Irrigation Manufacturer, Agriplas (Pty) Ltd, to consider developing the detector into a commercial product. The project was nominated by SANCID as contender for the WATSAVE award and won the international prize for 'Outstanding Contribution to Water Saving and Water Conservation in Agriculture' presented by the International Commission of Irrigation and Drainage in France in 2003. However, the Detector, which strives to make more efficient irrigation accessible to the majority of farmers, is in its infancy. In particular, there is a lack of understanding of how to deploy the device for furrow irrigation and how to interpret the salt and nutrient concentrations measured from solution captured by the detector. Most of the current requests for information and support arise from these applications; furrow irrigation and solution sampling. Ninety-five per cent of the research work on the Detector has been carried out on drip, micro-jet, and sprinkler systems. Most of the small-scale farmers, a key target audience, use furrow irrigation. The WRC *Report No TT 230/04* provides conflicting evidence on the usefulness of detectors for furrow irrigation. Pilot studies carried out in Australia have demonstrated that monitoring of salt and nitrate can provide very useful information to farmers. In South Africa, 54 people using Detectors were asked in a survey why they were interested in the technology and 20% replied that their interest lay in monitoring electrical conductivity and nutrients in the soil water sample collected by the Detector. Numerous enquiries about which solutes to monitor, what techniques to use and how to interpret the result as soon as the Detector becomes widely available are anticipated. Therefore, there is an urgent need to do the underpinning science in order to provide reliable information.

Estimated cost: R1 202 000
Expected term: 2005-2009

Real-time irrigation advice for small-scale sugar-cane production using a crop model, weather data and cellular communication
SASRI
No 1576

Water use efficiency in irrigated sugar-cane agriculture is notoriously low and could be increased dramatically if farmers applied established scheduling methods. A recent survey showed that 70% of sugar-cane farmers use dragline irrigation and that 50% of these use fixed irrigation schedules. This leads to severe over-irrigation in times of low water demand and impacts negatively on the profitability of irrigated sugar-cane production and on the environment. Pressure is also building for water users to demonstrate efficient use of the scarce and sought-after resource. The main reasons for non-adoption of scheduling technology as determined from a survey that was conducted were:

- The complexity of technology in relation to practical constraints on the farm
- An under-estimation of the benefits of accurate scheduling. This applies especially to small-scale growers who do not have access to computers, the Internet or expensive equipment.

The challenge therefore is to provide simple, practical and useful advice to farmers using state of the art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. The Agronomy Department at SASRI has developed a prototype of a system (called My Canesim) consisting of the following: Weather data recorded by automatic weather stations and remotely downloaded daily through the cellular network; a web-based simulation model that suggests irrigation actions; an Internet-based user interface for advisors and extension staff to enter field, crop and irrigation system data and to view simulation results; the automatic distribution of irrigation on/off advice in isiZulu through SMS technology to farmers' cellular phones. In a pilot case study, the system was implemented in 2004 on a limited scale in Pongola. Irrigation advice is provided to six small-scale growers and its impact monitored. Initial results are very promising and indications are that water savings of 30% and cost reduction of R1 400/ha could be achieved for small-scale growers. There is enough evidence to push for wider implementation of this service. These direct benefits are possible on 8 000 ha to more than 1 500 small-scale farmers in Pongola, the Makatini flats, and the Komati area. The technology could also be used by commercial growers on 56 000 ha. Indirect environmental benefits are reduced water extraction from river systems, and reduced runoff, deep drainage and water pollution.

Estimated cost: R256 000
Expected term: 2005-2008

Increasing water use efficiency of irrigated sugar-cane production by means of good agronomic practices
SASRI
No 1577

Low irrigation water use efficiency (IWUE) has been identified as a major problem in irrigated areas and this is even more important when the source of water is limited. Results reported by Olivier and Singels (2003) indicate that IWUEs of between 12 to 18t cane/100mm irrigation are possible as compared to 6t cane/100 mm averaged in the Onderberg at present. Agronomic practices such as the use of a trash (plant residues) blanket, growing suitable varieties, reduced row spacing and appropriate irrigation scheduling could increase the IWUE by saving water and/or increasing yield. Thorburn et al. (1999) have indicated that a trash blanket can reduce soil evaporation by an amount equal to 16% of annual rainfall. However, a trash blanket could also have a negative effect on the crop by slowing down initial growth, tillering and radiation interception and creating problems with trash worm and Eldana. Recent plant crop results by Olivier and Singels (2003) have shown that yields of a drip-irrigated plant crop can be increased by 10% and IWUE by 6% when changing row spacing from the standard single row spaced at 1.5 m to dual rows spaced at 1.8 m. The response to trash blanketing and high density planting depends on variety. According to Singels and Smit (2003) the very large yield responses to row spacing (53% per 1 m reduction) reported in Australia are the result of certain varieties having a low tiller production potential in the plant crop and therefore performing poorly in wide rows. It is believed that IWUE could be increased considerably by providing farmers with custom-made irrigation scheduling strategies for specific trash blanket, variety and row spacing combinations. Simple and easy-to-use irrigation calendars (with appropriate cycle and stand times) will be generated for areas with overhead irrigation by applying an accurate crop model to historic climate data. The outcomes of this research will include recommendations on best management practices (BMP, combinations of trash blanket, variety, row spacing, and irrigation scheduling strategy) for efficient and profitable use of irrigation water. Information will be available for the development of a trash blanket algorithm for the *Canesim* simulation model.

Estimated cost: R234 500
Expected term: 2005-2008

Integrating and upgrading of SAPWAT and PLANWAT to create a powerful and user-friendly irrigation planning tool
PICWAT
No 1578

SAPWAT is an easy to understand, user-friendly programme that is currently used by more than 200 users as an aid to the planning of irrigation requirements of crops and for training of farmers and students in both the commercial and the beginner-farmer category. Although it is a good educational aid for the understanding of crop irrigation requirements, it has some shortcomings, 2 of these being the inability to store the results of calculations and the inability to import weather station data for the expansion and updating of its existing weather station data. PLANWAT, the development of which was paid for by the International Water Management Institute, was initiated, amongst others, to overcome one of the above problems, namely the inability to store calculated data. SAPWAT is run out of PLANWAT and the resultant crop irrigation requirements are stored in a data file to enable the user to build an expected water requirement picture for backyard and community gardens, fields, farms, water users associations and for drainage regions. PLANWAT has a water harvest module where the output of SAPWAT is used to calculate required water harvest areas and required storage capacities for run-on situations of water harvesting, mainly for Third World situations. Its one drawback is that it does not provide for in-field water harvesting situations. In addition, as a planning tool the present combination of the 2 programmes does not provide for interactively determining the best potential scenarios of irrigation water use coupled to gross crop margin to enable farmers to select the best option for their circumstances. A need has been expressed that the capabilities of SAPWAT be expanded to also provide for automated or semi-automated calculations of irrigation water requirements for cases where mass calculations have to be done for river systems. The project will aim to integrate these programmes into a sensible unit and upgrade them to fulfil a more complete role as a planning aid for irrigation requirements of crops and the related economic scenarios.

Estimated cost: R537 500
Expected term: 2005-2008

Guidelines for irrigation management in pasture production
CSIR, Environmentek
1650

It is estimated that the total area utilised for irrigated pasture production is approximately 16% of the total area under irrigation. The returns generated from these enterprises make pastures one of the higher value crops produced under irrigation in this country. However, the management of the water requirements of pastures is not easy. They are often established on heavy and shallow soils that would not normally be considered for irrigation. Limited rooting depths and the need to integrate irrigation and grazing management further aggravate the position. Judicious management of irrigation is essential not only to utilise labour and water resources effectively and maintain production and profitability, but also to prevent serious degradation of land. Although management of dairy farming has now attained unprecedented levels of technology due largely to the availability of practical equipment and methods for planning, managing and monitoring most facets of dairy farming this does not apply to the irrigation of pastures. That still tends to rely on experience and tradition despite the increasing role of pastures in milk production.

It appears likely that it will be possible to develop a model or models that can be used to integrate the factors that must be taken into account when planning irrigation strategies and methods. It should also be possible to develop practical on-farm equipment and methods for recording and monitoring performance. There is, however, a dearth of reliable information and data pertaining to pasture water requirements to facilitate these developments.

Alternate methods to address this problem therefore need to be investigated and applied in practice in order to increase water use efficiency at farm level. This will be done initially by assessing the application of the main irrigation methods in conjunction with accepted grazing and irrigation management strategies and identifying opportunities for improvement. The second phase would target the development of databases on the fodder crops and their characteristics, climate, soils, irrigation and on the development of methodologies for measurement and monitoring. The validity and practicality of the material and equipment developed would finally be assessed in conjunction with the industry.

Estimated cost: R2 150 000
Expected term: 2006-2011

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams
Division of Aquaculture, University of Stellenbosch
No 1461

Most irrigation areas make use of on-farm storage dams to store water until it is required for the irrigation of crops. The existence of these dams presents an opportunity to utilise them also for fish production. Benefits associated with this dual use of

farm dams include the additional income associated with such an enterprise, the supply of fresh fish as protein source for local communities, the creation of additional employment opportunities and a potential reduction in fertiliser requirements for crop production, as a result of the enrichment of the irrigation water by fish food and excrement. Potential disadvantages of such an integrated water use system, are the operational restrictions the one use will place on the other (e.g. the dam cannot be completely emptied), concerns about the fitness of irrigation water for fish production and the fitness of aquaculture water for crop production and some irrigation systems. Although dual use is practiced in many countries, it is not common in South Africa. In the light of the potential benefits associated with the integration of aquacultural production with irrigation practice, it is proposed that the interaction between these two practices, the benefits and disadvantages associated with such integration and ways to maximise the benefits, be investigated for two case studies. Specific attention should be given to water quality effects and the precautionary measures that are required in order to maintain fitness-for-use need to be identified.

Estimated cost: R1 000 000
Estimated term: 2003-2008

Guidelines for sustainable use of grey-water in small-scale agriculture and gardens in South Africa
University of KwaZulu-Natal, School of Biological and Conservation Sciences
No 1639

The *White Paper on Agriculture* emphasises food security. Since household and urban food gardens form part of the spectrum of production systems and processes that can contribute to food security, they are supported by government. However, a shortage of water to supplement rainfall often limits the application potential of these systems. The use of grey-water may overcome this limitation by providing a dependable water source that is under the control of the household gardener. Grey-water is the untreated household effluent that is produced from baths, showers, kitchen and hand-wash basins as well as washing machines. More than half of the indoor household water use is normally used for these purposes and can thus potentially be intercepted by the householder for additional uses. Initial indications from a scoping study to evaluate the fitness-for-use of grey-water in urban and peri-urban agriculture are that there is considerable potential to use this largely untapped source to augment household food security. However, there are also risks involved with the practice that need to be better assessed and quantified under controlled conditions. These risks are largely associated with factors that affect the sustained productivity of the irrigated soil and health considerations. A workshop is planned to prioritise these risks and finalise the appropriate experimental approach to address them before finalising the terms of reference and soliciting project proposals.

Expected cost: R1 670 000
Estimated term: 2005-2008

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agroforestry, woodlands and forestry plantations

Water use in relation to biomass of indigenous tree species in woodland, forest and/or plantation conditions
CSIR
No 1462

Information on the water use of trees is essential in order to manage different land-use activities. Currently no information is available on the water use of indigenous trees in relation to biomass production. The central question that must therefore be answered is the following: What is the net benefit of water used by indigenous woodlands compared to commercial forest plantations? For this project it will be important to consider a limited number of species for stands of indigenous trees. Since the emphasis is on water-use efficiency, the water use for the harvestable above-ground biomass production for different end uses should be quantified. The focus should be on slow-growing and initially fast-growing indigenous trees in defined catchments or bio-climatic zones. The following climatic conditions and regions should be considered: Cold-tolerant (Highveld, Piet Retief); subtropical (coastal and Mpumalanga Lowveld); and temperate (KwaZulu-Natal midlands, Mpumalanga escarpment and Transkei in the Eastern Cape). The water use/biomass relationship of indigenous trees and comparison with existing information for trees in commercial forests must enable future comparisons of the productivity and value of water used under different tree production systems.

Estimated cost: R2 249 616
Estimated term: 2003-2008

Agro-forestry systems for improved food production through the efficient use of water
Environmentek, CSIR
No 1480

Less than 15% of land area in South Africa is arable. This implies that there is very limited scope for conventional food production, both on irrigated and dry-land. In addition to limited arable land, South Africa is a water-scarce country. Its rainfall is below the world average, and its distribution is somewhat unreliable.

The relatively low rainfall and limited arable land make it imperative to effectively and efficiently use these natural resources for food and fibre production. This is even more important for emerging and subsistence farmers who often lack access to information and use of production technologies. Smallholder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands.

In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor.

This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally.

Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa.

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale),

incorporating local knowledge through participative assessment.

Estimated cost: R3 250 000
Expected term: 2004-2009

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Integrating flood-plain agriculture into a diverse rural economy by enhancing cooperative management: A case study of the Pongola
Institute for Natural Resources
No 1299

The effective management of the Pongola River flood plain has been unsatisfactory ever since the completion of the Pongolapoort Dam. This study aims at promoting effective cooperative management of the river system on a sustainable and democratic basis. Lessons learned here will contribute to formulation of policies and institutions to achieve sustainable use of river systems in rural South Africa. This project is strongly based on the principles of a participative action plan.
The aims of the project are to:

- Learn about promoting effective cooperative management around sustainable use of river systems in rural areas
- Redirect the pattern of resource use on the Pongola River flood plain towards a shared vision reflecting a diverse and sustainable economy
- Establish a confident and capable team of researchers drawn from previously marginalised sectors.

Estimated cost: R880 000
Expected term: 2002-2006

The effect of the introduction of agroforestry species on the soil moisture regime of traditional cropping systems in rural areas. Phase II: On-farm trials of alternative agro-forestry systems
Environmentek, CSIR
No 1351

One of the major constraints in rural farming systems of the Upper Thukela is the shortage of adequate and good quality grazing during the dry winter season. Unfortunately, supplementation of feed using commercial supplements is difficult because the supplements are expensive and not easily available in remote areas. Provision of alternative sources of fodder such as tree leaves and pods can increase production. The introduction of tree species for fodder should decrease the grazing pressure on the existing grassland. This will result in improved basal cover, decreased soil erosion and promote greater water infiltration. The project aims are:

- To determine the effect of different agro-forestry systems on increasing fodder production in rural farming systems
- To determine the effect of agro-forestry practices on soil water availability to traditional crops (e.g. maize)
- To determine whether the inclusion of trees in traditional cropping systems can enhance the infiltration of rainfall and prevent soil loss
- To compare the water use of an indigenous fodder tree (*Acacia karoo*) and an exotic fodder tree (*Morus albus*), in order to test the hypothesis that indigenous fodder trees are more conservative water users than exotic tree species.

Estimated cost: R1 500 000
Expected term: 2002-2011

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province
Zakhe Agricultural College
No 1465

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exerts even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention should be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods should be analysed.

Estimated cost: R3 000 000
Expected term: 2003-2009

Best management practices for smallholder farming on two irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research
University of Fort Hare
No 1477

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. The research project on 'best management practices for small-scale subsistence farming' therefore requires commitment and co-operation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000
Expected term: 2004-2009

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province
University of Fort Hare
No 1478

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production.

The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area.

Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system.

The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 000 000
Expected term: 2004-2009

Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods
Rural Integrated Engineering (Pty) Ltd
No 1575

The rural landscape of South Africa is characterised by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Expected cost: R2 750 000
Estimated term: 2005-2009

Nutritional value and water use of indigenous crops for improved rural livelihoods
University of Pretoria, Centre for Nutrition
No 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (WRC *Report No 944/1/04*). It is also important to determine the nutritional value and water requirements of these crops. The best combination between indigenous crops and a range of home-grown vegetables, and other foodstuffs to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (WRC *Report No 1267/1/04*). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosa, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households.

Expected cost: R2 850 000
Estimated term: 2005-2010

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities
University of the Free State, Agricultural Economics
No 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on bio-physical aspects of in particular infield RWH&C has been done (see WRC *Report No 1176/1/03*). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC *Report No 1267/1/04*). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low- potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000
Expected term: 2006-2011

Programme 2: Integrated water management for profitable farming systems

Water resource management for profitable small-scale farming along the banks of the Orange River
Department Agricultural Economics, University of the Free State
No 1354

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According to the provincial department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment.

The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa.

Sub-aims are to:

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000
Expected term: 2002-2008

Revitalisation of provincial fish hatcheries and training facilities to promote profitable aquaculture
Rhodes University, Department of Ichthyology and Fisheries Science
No 1580

A baseline study on the *Contribution of Aquaculture to Rural Livelihoods in South Africa* has been done by Rhodes University (WRC *Report No TT 235/04*). This study showed that the present factors constraining aquaculture in rural areas were mainly a consequence of a lack of policy and institutional capacity and that the development of rural aquaculture will depend principally on a public sector led intervention, inclusive of technical support and fingerling supply. The study revealed that there are many state-owned hatcheries and training facilities falling under various government departments that are unproductive, privatised, or defunct. Though not assessed these assets are worth millions of rand. Based on the survey results it was further agreed that the involvement of the private sector in rural aquaculture would be essential for sustainable growth. As policy issues were being addressed by the national Department of Agriculture, it was suggested that the WRC should support the undertaking of workshops in preparation for participatory action research (PAR) with the various public and private sector stakeholders to appraise the potential role of these hatcheries in the light of emerging policy, and where applicable to develop a framework for a community private public partnership (CPPP) to revitalise government hatcheries that are currently under-utilised. The workshops have been completed and the PAR can now proceed. The PAR is a process which includes research and implementing goals and objectives. Stakeholders in the Limpopo, Mpumalanga and Eastern Cape provinces will be engaged and an end-point will be identified (for example, through CPPP revitalising a specific government hatchery). Once the end-point has been identified, the role of the PAR implementers would be to actively facilitate and record the process, so that it is successful and repeatable elsewhere.

Expected cost: R2 250 000
Estimated term: 2005-2010

Development of training material for extension in irrigation water management
University of Pretoria, Agricultural Economics, Extension and Rural Development
No 1649

The revitalisation of irrigation schemes and irrigation management transfer is accepted policy in South Africa (Department of Agriculture, 2003). Implementation of this policy can, however, not succeed without extension support. In the process of integrated development planning (IDP), extension services are also the essential link between government and rural communities who are dependent on agriculture. In both cases extensionists therefore perform an important function to promote agricultural development, which in turn leads to community development. It is generally recognised that extensionists provide the link between research output and solving the perceived problems which farmers experience. All types of farmers, but specifically emerging farmers, are dependent on extension services as a source of information and knowledge. This has been confirmed by a survey amongst emerging irrigation farmers (WRC, 2003). Discussion forums organised by the WRC in all provinces between 2000 and 2003, in which a wide range of farmers participated, have highlighted that the extension link has deteriorated in recent years and has become less effective. Presently information is available on various bio-physical and socio-economic aspects of irrigation management. Irrigation-related courses are also presented by universities and colleges. However, this information is not presented in the required format and the courses are not specifically targeted to be useful for extensionists in their work environment. Extensionists therefore do not have the appropriate knowledge base and skills to do their work. In many cases this results in a lack of confidence amongst extensionists, decline in their credibility and withdrawal from the community which they must serve. There is an urgent need to restore the self-esteem of individuals and improve the service delivery of the extension profession.

Extensionists require in-service training on all aspects of irrigation management, to meet the demands of subsistence, emerging and commercial smallholder farmers. Training material must be developed or adapted for this purpose. This will enable extensionists to become more effective, with the benefits not being limited to farmers only, but having a positive impact on the community in which extensionists and farmers live.

Estimated cost: R1 870 000
Expected term: 2006-2011

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Managing salinity associated with irrigation in selected areas in South Africa
University of the Free State, Department of Soil, Crop and Climate Sciences
No 1647

Because crops use water consumptively it is an inevitable consequence of irrigation that the salts in irrigation water are being concentrated in the soil. Since crop yield, in turn, is reduced at high soil salinity levels, it is a prerequisite for sustainable irrigation (and to protect the soil resource base) that soil salinity be managed to remain at levels that support acceptable crop yield. Current practice is to achieve this by applying water in excess of crop requirement, whereby some of the accumulating salt is leached from the root zone. The practice to leach salt from soil, which ensures the sustainability of

irrigation from an agricultural perspective, has the undesirable side effect of salinisation of ground and surface waters. The negative impact irrigation return flows have on water quality is observed in practically all irrigation schemes. Because of the negative impact that 'irrigation wastewater' (leachate and drainage water) have on other water resources, there is an increasing range of initiatives that are being investigated both locally and internationally to improve the way in which to manage this impact at both farm and scheme level.

Even though there is concern about the environmental impact of irrigation, the need for increased agricultural production and assurance of supply seem to necessitate the continued expansion of irrigation on a global basis. In view of the increasing demand for water resources and irrigation's relative inability to compete with other sectors for high quality water sources, it is foreseen that in the case of South Africa, the future expansion in irrigation area will increasingly have to rely on poorer quality water. By making use of poorer quality (waste) water, irrigation would also be able to free up better quality water for other productive uses. However, such a move will make even greater demands on the ability of irrigators and water managers to manage salinity and its effects on crops and environment.

It is thus clear that the sustainability of irrigated agriculture will to a large extent be determined by our collective ability to manage the problems associated with salinity. Much of the success of such management strategies will depend on the success with which the 'wastewater' can be utilised within irrigated agriculture. Although much in this regard has already been learnt locally and internationally, the practical application of these lessons is lagging behind. It is thus envisaged to conduct a project that would synthesise current knowledge and select the appropriate practices for application and testing in a number of case study areas with existing problems. It is anticipated that this evaluation would enable the development of specific guidelines for the management of the case study areas with as aim to bridge the gap between existing knowledge and its application, the formulation of generalised recommendations about the implementation of sustainable solutions to the management of salinity on irrigation schemes, the identification of incentives that can be applied to modify the behaviour of water managers at farm and scheme level and the identification of research or knowledge gaps.

Estimated cost: R2 400 000
Expected term: 2006-2010

Programme 2: Impact assessment and environmental management of agricultural production

Modelling non-point source (NPS) pollution in agriculture from field to catchment scale
Sigma Beta Consulting
No 1516

It is increasingly recognised that non-point source (NPS), or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore increasingly accepted that it is unfeasible to properly manage water quality without addressing the contribution from non-point-sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. Since most of the land area is utilised for agricultural activities, agriculture has both locally and internationally been implicated as a major source of NPS pollution. It is therefore necessary to assess the contribution that the different agricultural activities make to the different manifestations of NPS pollution, to devise the means through which these can be controlled and to determine and predict the effect that control measures will have to reduce NPS pollution. Understanding the production, delivery, transport and use components of agriculture-derived NPS loadings of water resources and having a predictive ability about the fate of agriculture-related NPS constituents are discrete research themes that will enhance the usefulness of the existing guidelines in the agricultural domain. The contribution of irrigation activities towards the salinisation of water resources has been studied for quite some time and is currently still receiving attention. Other water quality issues of concern that are potentially aggravated by agricultural activities are eutrophication (through fertiliser leaching and wash-off from human settlements), sediments (as a result of erosion), pathogens (from intensive animal production units), pesticides (through the application of insecticides, fungicides and herbicides) and some heavy metals. Although agricultural activities that give rise to the latter water quality issues have been the subject of previous studies, the present level of knowledge concerning them is not as advanced as for irrigation-induced salinisation of water resources. The project will address those issues that require priority attention, with regard to NPS pollution.

Estimated cost: R5 000 000
Expected term: 2004-2009

Applications of rainfall forecasts for agricultural related decision making in selected catchments
University of KwaZulu-Natal, School of BEEH
No 1646

The South African climate is highly variable over short and longer periods. This inter- and intra-seasonal variability is likely to be amplified by the global change in climate. Agricultural production is intrinsically linked to climate variability. Many agricultural decisions are made based on climate (short, medium and longer term) information and assumptions. Farmers need information to help them plan for planting, irrigation and harvesting of their crops.

Weather forecasting can aid users to make more informed decisions and assist in planning activities. They have the potential to reduce risk in the long term and improve water use efficiency. Forecasting involves computer models, observation and knowledge of trends and patterns. Using such tools, meteorologists can reasonably forecast weather conditions up to five days in advance. Longer lead-time forecasts (weeks, months) are referred to as climate forecasts. Such forecasts, usually made in terms of categories (above, near and below normal) and probabilities, are becoming more skilful as research progresses. However, gaps exist between the weather and climate forecasts and linking them to agrohydrology and applications in agricultural decision making. The project aims to develop techniques and models for translating forecasts of up to one year in advance into applications for decision-support.

The WRC has funded several projects over almost two decades on research on climate variability with a focus on forecasting, modelling and database development. These include *inter alia*:

- **Development of a raster database of annual, monthly and daily rainfall for Southern Africa** (WRC *Report No 1156/1/04*)
- **A flood nowcasting system for the eThekwini Metro: Volume 1 and 2** (WRC *Report No 1217/1/04 and 1217/2/04*)
- **Spatial interpolation and mapping of rainfall (Simar): Volume 1-3** (WRC *Report No 1151/1/04; 1152/1/04 and 1153/1/04*)
- **Regional model development for simulating atmospheric behaviour and rainfall over Southern Africa** (WRC *Report No 1261/1/05*)
- **Dynamic modelling of the present and future climate system** (WRC *Report No 1154/1/04*).

These and other projects have resulted in more comprehensive datasets and a better understanding of weather and climate variability and refined forecasting tools. It is therefore in the interest of the WRC to see this research utilised.

The 2001 Strategic Plan for South African Agriculture states that one 'component of the comprehensive risk management strategy is an early-warning system that includes adequate access to and utilisation of timely, accurate, relevant, and free information about the weather'. Since the end of 2002, the national Department of Agriculture has been advising farmers on climate conditions and practices to follow, based on a long-term climate outlook. It is envisaged that this project will develop an early warning system with different lead-times that could reduce farmers' susceptibility to adverse weather conditions. Although the project will focus on two or three critical catchments, the findings of this study will be extrapolated to other catchments.

Estimated cost: R2 850 000
Expected term: 2006-2011

NEW

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of fruit tree/orchard crops
CSIR, Natural Resources and the Environment
No 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate, soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, subtropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectarage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R4 400 000
Expected term: 2007-2013

Water use of drought-tolerant food crops
University of KwaZulu-Natal, Crop Science
No 1771

A significant proportion of the South African population experiences food insecurity and malnutrition (micronutrient deficiency) despite living in a country that is a net exporter of food. One of the main food security challenges facing the country is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. About 14.3 million people are vulnerable to food insecurity, particularly women, children and the elderly. There is therefore a need to increase the content of the South African food basket particularly for the poorest households living in rural areas. However, drought is one of the major hurdles facing agriculture in sub-Saharan Africa. South Africa, like many countries in the region, is prone to severe water shortages which seriously impacts on the availability of food. One way to combat inadequate availability of water is to develop or select crops that are more tolerant to water stress. Indigenous edible plants that are resilient have sustained rural populations in developing countries for centuries. These traditional crops are native to specific localities and are therefore better adapted to the local environmental conditions and cultivated without the need for much external inputs such as agrochemicals or a high water requirement. However, information on the utilisation of indigenous crops in South Africa is not well documented. Moreover, no comprehensive overview of the spectrum of food crops available for food production in South Africa in relation to drought tolerance, crop adaptability, economic importance and water use characteristics has been conducted. This project seeks to understand the water use characteristics of drought tolerant crops through the use of empirical measurement and crop growth models. The parameters needed for modelling will guide the empirical research.

Estimated cost: R3 900 000
Expected term: 2007-2013

Scoping study on water use of crops/trees for biofuels
University of KwaZulu-Natal, School of Bioresources Engineering and Environmental Hydrology
No 1772

Biofuels such as bio-ethanol and bio-diesel have been widely publicized as the means to sustainably meet South Africa's future energy needs. The establishment of an economically viable biofuels industry is increasingly becoming an attainable prospect due to: technological advances; high oil prices; global commitment to limit greenhouse gases and to reduce global warming, the requirement to diversify energy supply and the enormous potential for local job creation, particularly in the agricultural sector. Various government departments including Minerals and Energy, Agriculture and Science and Technology are to begin an initiative to explore biofuels as an important component of the energy mix. Biofuels are renewable liquid fuels derived from, among other sources, the sustainable agricultural production of field crops and tree crops. South Africa is a water scarce country whose rainfall is below the world average and whose rainfall distribution is, temporally and spatially, unreliable. Furthermore, the country has limited supply of water for irrigation. Therefore, the prudent selection of crops that will ensure the efficient and sustainable use of limited water resources will be essential. This project is addressing the suitability of various agriculturally based products. It focuses on identifying the most suitable crops for biofuel production and establishing the available knowledge on water use of these crops. It will determine the water requirements of crops where information on water use is lacking but crop parameters are available by applying appropriate models.

Estimated cost: R250 000
Expected term: 2007-2008

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

A quantitative investigation into the link between irrigation water quality and food safety
University of Stellenbosch, Food Science
No 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in, e.g. informal settlements and failing water treatment in, e.g. non-operating sewage works. This water is often used for irrigation and there is a direct relationship between irrigation

water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers, while there is also an increase in the susceptible individuals. A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and internationally. The problem of contamination of irrigation water and food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets. Biomonitoring of irrigation water quality is currently fragmented and not regularly published. Little is therefore known on a national level regarding the contribution of irrigation water and the associated, potentially contaminated raw produce to the burden of disease. Consequently little action is taken to remedy the situation. A clearer understanding of the problem is urgently required to make inputs for policy formulation and regulation to reduce contamination of irrigation water. This project will investigate the links between irrigation water quality (microbial and nutrient chemistry) and food safety in commercial as well as subsistence agriculture and give guidance towards treatment options of irrigation water to ensure food safety. This research project will therefore evaluate the extent of the problem regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two and provide recommendations on the way forward in terms of treatment of irrigation water. To achieve this, the main tasks include a baseline study on the extent (types and quantities) of contamination found in irrigation water as well as contamination found on the irrigated raw produce (fruit and vegetables) before and after harvest at the selected sites. The final report will document the extent of contamination found in irrigation water and on the irrigated raw produce; the links between contamination on raw produce and irrigation water applied; and make recommendations for further research in respect of validation of results and treatment options.

Estimated cost: R3 300 000
Expected term: 2007-2012

Scoping study to investigate the possible pollution of endocrine disrupting compounds (EDCs) from agricultural activities in South African water systems
Private Consultant: Mrs AEC Burger
No 1774

In crop production and animal husbandry a number of chemicals are used that have an influence on the endocrine systems of humans and animals (EDCs). The intake of these chemicals may lead to a variety of problems in the reproductive, neurological, immunological systems as well as thyroid function in humans and animals. Very little is known about the occurrence, magnitude and influence of these chemicals in South African water systems and food products. In agricultural practices chemicals are mostly used for pest control and fertilisation of crops and for pest control, disease (parasite control) as well as growth promoters in animal husbandry. Not all chemicals used in agriculture have EDC properties. In this project a framework will be developed to determine the influence of agricultural chemicals with EDC activity in water systems and the following steps will be taken:

- A survey will be done on the type of crop cultivated. Each crop has its own set of chemicals registered for use
- Determine whether farmers are using only registered chemicals or all 'available' chemicals
- Determine the chemicals used for the crops (based on questionnaires addressed to farmers, co-operatives, local merchants, etc.)
- Select the chemicals with EDC properties with literature survey on their persistence in the environment
- Collect data on the volumes used and frequency of application, practises on mixing of chemicals on the field, and disposal
- Study of the geological make-up of the area to determine whether chemicals may reach rivers or dams. Information regarding the geological make-up of the areas will be obtained from the available geological survey.

The main outputs will be reports on crop production and animal husbandry in selected catchment areas; agricultural chemicals used in these catchment areas; level of pollution of water systems in the catchment areas and the probability of agricultural chemicals with EDC properties entering the water system.

Estimated cost: R250 000
Expected term: 2007-2008

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa
ARC, Institute for Soil, Climate and Water
No 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorized as ultra-poor. Although the country is self-sufficient in food production, about 14 million people are reported to be vulnerable to food insecurity and 43% of households suffer from food poverty. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas.

Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned but used communally by farmers for grazing domestic livestock and harvesting natural products such as fuel-wood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterised by abandoned croplands that are infested by weeds and grasses. In communal areas where individuals share land and water resources understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is dependent upon the functioning of the institutional arrangements.

Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop lands in communal areas will be produced.

Estimated cost: R3 200 000
Expected term: 2007-2013

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)
Umhlaba Consulting Group
No 1776

Water harvesting and conservation practices have been tested and demonstrated to be sustainable and contribute to food security. Many of these techniques and practices have been documented in the form of research reports and information material for public interest, but not packaged as training material for the end user. In addition, advisors and farmer support personnel such as extension services are often ill-informed and inadequately trained in agricultural water management including water harvesting and conservation.

High illiteracy, particularly among the rural population, limits the ability of farmers to access information and utilise new technologies. There is, therefore, a need for accredited yet appropriate training material for certified trainers and learners (farmers). Training, education and skills development will need to follow a broad based approach that is aligned to government initiatives such as the Joint Initiative on Priority Skills Acquisition (JIPSA) and grounded on Outcomes Based Education (OBE) and Adult Basic Education and Training (ABET) principles. This project will develop a comprehensive learning package for the application of WH&C for household food production and poverty alleviation in rural areas. It will identify the existing unit standards for training in WH&C and fill the gaps in learning material by adopting and adapting available material and developing a comprehensive package (NQF level 4/5 facilitators guide for trainers, ABET levels 1 and 2 learning material for learners and assessment guide). The learning package will be tested in the field with trainers, facilitators and learners.

Estimated cost: R1 950 000
Expected term: 2007-2012

Scoping study on indigenous water harvesting and conservation (WH&C) practices
Umhlaba Consulting Group
No 1777

South Africa is an arid country with a very limited supply of freshwater. In recent years, greater recognition has been given to water harvesting practices as a means of supplementing much needed water for agriculture and other purposes. However, water harvesting and conservation practices are not new. As water harvesting has been practiced for many millennia in many parts of Asia and Africa, a large number of techniques developed. Early (indigenous) water harvesting and conservation techniques made it possible to cultivate arid and semi-arid areas which might otherwise not have supported farming or permanent settlements.

Indigenous water harvesting systems found in North Africa and West Asian countries have been well documented. Although indigenous water harvesting systems have been in existence in sub-Saharan Africa, including South Africa for many years these systems have not received much recognition nor have they been documented. This project seeks to record the history of water harvesting in South Africa and to document the indigenous water harvesting practices. In addition it will recommend potential technological improvements to indigenous practices that are still in use.

Estimated cost: R250 000
Expected term: 2007-2008

Programme 2: Integrated water management for profitable farming systems

Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement
WSM Leshika (Pty) Ltd
No 1778

According to the National Water Resource Strategy of 2004, national water conservation and demand management (WC & DM) strategies are being developed. The strategy for irrigated agriculture provides a framework of regulatory support and incentives to improve efficiency, with a plan of action towards delivering amongst others the following outputs:

- Implement measures that reduce wastage
- Convince users to progressively modernise their water conveyance infrastructure and irrigation equipment.

The recently published Water Conservation and Water Demand Management Conditions for Water Use Sector Authorisation (DWAF, 2006) imposes a duty to measure, record aspects of water use and requires that 'the licensee shall measure the amount of water supplied to each farm or user on a monthly basis using an appropriate flow measurement device'. The WRC has published reports and guidelines for the direct and indirect measurement of water on irrigation schemes in response to the practical need to measure and manage water effectively and efficiently. However, in most cases the water management system currently in operation does not incentivise water measurement, and consequently measurement of water use and volumetric charging is not widely practiced. This project will facilitate a process towards effective implementation of water measurement at river, irrigation scheme and farm level in South Africa. In order to achieve this, end users of water measurement technology will be made aware and convinced to adopt the technology. Specific attention will be given to technical constraints and financial justification for implementation of the technologies for water measurement. This will require purposeful capacity building and training of end-users such as farmers while using the model of 'train-the-trainer', which has been found to be most successful. In this process a common understanding of the practical requirements of water measurement by water users, water managers and regulators will have to be reached. Therefore it is necessary to obtain support of the DoA and DWAF on training for adoption of water measurement. Since water user associations (WUAs) will increasingly provide an advisory role, the managers of WUAs and leader farmers who they serve, will be targeted in order to achieve sustainable implementation of water measurement. The intention is to interact with these stakeholders as part of the preparatory phase; determine the incentives for water measurement as part of the analysis phase; and practically demonstrate how to undertake effective water management in the implementation phase. The final output of this technology transfer project will be an overarching report that documents the implementation process, the lessons learned and guidelines towards general implementation of water measurement.

Estimated cost: R1 400 000
Expected term: 2007-2011

Assessment of the contribution of water use to value chains in agriculture
University of the Free State, Agricultural Economics
No 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the Agriculture Sector Plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-ranging programme is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises: how can emerging producers be included in the mainstream of the economy? Only by obtaining access to available resources or assets in agriculture, can an

impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the economy. It will investigate whether emerging farmers, who are producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development. The main outputs will be firstly, a conceptual framework based on the literature review of the value chain analysis with specific reference to water utilisation and competitiveness in agriculture. Secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticultural and field crop industries. Thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain; optimisation of water use in the whole value chain; mainstreaming of marginalised participants in the economy by integration in the value chain; employment creation and poverty reduction through the value chain; and improving competitiveness in the value chain.

Estimated cost: R2 430 000
Expected term: 2007-2012

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KSA 5: Water-Centred Knowledge

Dr Heidi Snyman | Director |
Water Research Commission

SCOPE

Over the past few years, KSA 5 has continued to place focus on the development and protection of knowledge resources. The building of knowledge management capabilities, in terms of technology and fundamental business processes has made a contribution to the effectiveness of the WRC. The embodiment of the culture of knowledge management forms the basis of the WRC mission and is the focus of the WRC vision, that of becoming a true knowledge hub. Over the past year, there has been a determined effort to continue to focus on the basic building blocks necessary to support the knowledge management objective of the WRC. This KSA, for example, has taken the bold step of implementing the Fund Management System (FMS).

Driven by external needs, the WRC continues to strive to improve its position as the dynamic hub for water-centred knowledge, innovation, and intellectual capital in South Africa and even further afield in Africa and the developing world. There has been recent interest in the WRC strengthening their position in Africa and abroad as a result of the success experienced within the past 3 years. The knowledge to be managed is both explicit, documented knowledge and tacit (subjective) knowledge. Management of knowledge in the WRC will therefore entail all the processes associated with the identification, sharing and creation of knowledge. This will require systems for the creation and maintenance of knowledge repositories, and for the support of the cultivation and facilitation of the sharing of knowledge and organisational learning. Internally, for the WRC to succeed in knowledge management, it has to view knowledge as an asset and to develop organisational norms and values, which support the creation, and sharing of knowledge, both internally as well as externally.

Therefore, in general, this KSA will focus on deriving value from its intangible assets, e.g. full utilisation of information systems to manage data, information and knowledge; full utilisation of a system that tracks who is using our knowledge products (technical reports); increasing the circulation of our journals; improving document and information management internally; and the management and/or administration of research projects.

OBJECTIVES

Knowledge management in a knowledge-intensive organisation like the WRC has a strategic support function as well as being an enabler. In addition, the KSA has broadened its scope to actively support the water sector in its strategic knowledge initiatives. The functions of public relations/communication (KSA7) have been incorporated in this KSA; as a result the objectives of the KSA have been expanded as follows:

Internally focused objectives

- To enhance the core processes of research support and management by improving access to relevant knowledge
- To support the emergence of the culture of knowledge management
- To develop and maintain consistent data architecture to enable the flow of content through an FMS to support the core business of the organisation
- To support innovation and commercialisation through proper management and protection of the WRC's patent portfolio.

Externally focused objectives

- To participate and lead knowledge-dissemination initiatives including sharing and networking supported by functional, user-friendly research and water information systems
- To build and strengthen knowledge links with Africa and globally
- To continuously improve knowledge transfer and dissemination through feedback from users, dissemination of reports, guides, scientific and non-scientific journals, and by providing support to other technology transfer initiatives
- To develop a state-of-the-art communications system, to enable quick, meaningful contact between the WRC and the water sector/ stakeholders
- To continuously develop better and more efficient knowledge dissemination tools and channels, especially to DWAF
- To promote the WRC through engaging with all stakeholders and customers, either directly or through the media, and providing them with information about the WRC's activities, products and accomplishments.

THRUSTS

The achievement of the above objectives will be supported by a structure or a framework of a number of thrusts (which form a number of management areas/functional groups). A creative approach to knowledge management will be achieved within these management areas. The thrust structure (management areas) as described in the previous year's plan was reviewed and will remain unchanged:

THRUST 1: RESEARCH COORDINATION AND STRATEGIC RESEARCH ADVICE

The focus of this thrust will be to coordinate the research cycle in the WRC and provide strategic research advice through facilitation, feedback and review.

The core business of the WRC is to invest in developing the water knowledge base in South Africa. This is primarily done through investing in water research on a priority basis through third party agreements. An FMS has been developed to facilitate the coordination of the research cycle in the WRC. Consequently the functions will entail:

- Overseeing the development of the FMS

- Driving the content and population of the FMS
- Producing management reports from the FMS for the CEO and the WRC Executive
- Overseeing the annual call for research proposal cycle and preparing the necessary documentation
- Reviewing project and finalisation reports and submitting consolidated reports to the WRC Executive.

The WRC is a knowledge organisation and hence the fundamental processes are knowledge-based, thereby creating value for the WRC and its stakeholders. Thus the WRC is well positioned to offer strategic research advice on water-related issues to a range of stakeholders. This function will involve:

- Provision of independent expert research advice to key stakeholders such as the Portfolio Committee on Water Affairs and Forestry and DWAF
- Technology prospecting and foresight.

THRUST 2: KNOWLEDGE DISSEMINATION AND PROMOTION

The focus of this thrust will be to develop knowledge-sharing and knowledge-dissemination instruments to support the objectives of the WRC (of being a knowledge hub) in its knowledge-creation and learning activities and the core process of knowledge generation. It will develop a culture based on the understanding that 'knowledge resides in the user and not in the collection of information.' Thus there will be a need to develop a clear link between this KSA and the other water KSAs, who will be at the core of the knowledge management activities.

Further, this thrust will oversee that the WRC maintains access to the necessary information to make appropriate decisions internally as well as externally. This management area will also act as a resource centre to meet information requirements of the WRC and the water sector in general and will lead and participate in other knowledge-sharing and knowledge-dissemination activities. It will also strengthen the WRC's ability to exchange information and data on developments around water management issues, while continuing to disseminate technical reports and technology transfer documents.

This KSA also acknowledges that the knowledge base must remain dynamic, and globally competitive. In pursuing this goal, there will be increased focus to collaborate with other countries and/or researchers in the international arena. Such initiatives will be pursued while leveraging the WRC's funding for these initiatives.

This thrust will also focus on promoting the WRC through engaging with all stakeholders, especially DWAF and customers, either directly or through the media, and providing them with information about the WRC's activities, products and accomplishments. The purpose of promoting the WRC in this way is to realise crucial benefits for both the WRC and its stakeholders/customers.

THRUST 3: PUBLICATIONS

This thrust focuses on the WRC publications and the internal library and the management of the publications, including maintaining library and information services. The key focus is on dissemination of knowledge created via the support of the WRC as well as other sources (originating from the national and international arena) through publication of an internationally rated journal and the ongoing publication of research reports and technology transfer (TT) documents. Working with Thrust 2, there will an effort to support proper packaging for better sharing of knowledge. There will be an added effort to improve the quality of the reports and other knowledge-dissemination media. This will entail a focus on e-publishing and e-business.

THRUST 4: INTELLECTUAL PROPERTY MANAGEMENT

In order to encourage successful invention and subsequent solid patents and commercialisation, the WRC will continue to address the creative needs of the researchers and foster an inventive environment within the research area and engage with the researchers at all levels. By supporting the creation of and protecting technological developments the WRC strives to further improve knowledge transfer (utilisation and commercialisation) of its research results (in collaboration with its research providers and the water sector at large) where and when applicable.

THRUST 5: BUSINESS SYSTEMS INFRASTRUCTURE

This thrust will continue developing the interface between service providers and the WRC and users of WRC knowledge products and the WRC, while enhancing the search engines for information hunters. The creation of virtual communities of users and customers is among the key priorities of our vertical portals to be developed. The challenge of walking the tightrope between adopting the latest technologies and remaining up to speed with ongoing business and technology developments is becoming more acute in the e-world.

BUDGET FOR 2007/08

The approved budget funding of the research portfolio for 2007/08 leads to a committed funding budget of R14 376 018. The focus of this portfolio will continue along the current trends.

CORE STRATEGY

Strategic context

The WRC through its water KSAs generates a vast array of water-related information products which contribute to addressing the critical water problems that South Africa experiences. A critical challenge is the explicit and systematic management of this vital information along with its associated processes of gathering, organising, diffusing, using and exploiting that information.

The value of research generated by the WRC is increasingly being measured by how readily the research results are translated into useful products and services. This requires knowledge management systems (KMSs) that effectively link the information generated by the WRC research portfolio to the knowledge users (those who ultimately take action or make decisions that initiate action), such as national and local government officials, farmers, community-based organisations, politicians and researchers.

There are 2 approaches to building a KMS: the process/task-based approach and the infrastructure/generic system-based approach:

- The process/task-based approach focuses on the use of information by participants in a process, task or project in order to improve the effectiveness of that process, task or project. This approach identifies the information and knowledge needs of the process, where they are located, and who needs them. The KMS is designed to capture information unobtrusively and to make information available when needed to whom needs it.
- The infrastructure/generic system-based approach focuses on building a base system to capture and distribute information for use throughout the organisation. Concern is with the technical details needed to provide good mnemonic functions associated with the identification, retrieval, and use of information. The approach focuses on network capacity, database structure and organisation, and knowledge/information classification.

The first approach is predominately utilised in the water KSAs, where an understanding of the water-related knowledge needs are developed and specific products developed for transfer to the specific knowledge users. The **Water-Centred Knowledge** KSA will support this process by producing instruments or tools that will support the knowledge process within the WRC. This includes communication, translation, conversion, filtering, rendering and protection of research results. The capability to offer strategic research advice will also be further developed within the KSA.

A major task is to establish and maintain knowledge repositories within the WRC to capture and distribute information throughout the water sector and supporting the implementation processes of DWAF. A critical aspect is also to maintain and further develop the information, communication and technology (ICT) infrastructure to support the knowledge repositories and the efficient functioning of the organisation as a knowledge hub.

Needs analysis

Developing a proper understanding of the knowledge users and their needs is the main determinant of how information should be packaged. The **Water-Centred Knowledge** KSA has both internal and external customers and, as identified previously, are the same as described before. Previous stakeholder consultations through a knowledge dissemination survey have demonstrated the need to improve knowledge dissemination via the electronic media. Improving the efficiency of downloading information from the WRC webpage, and easy access to information will be implemented in the coming year.

Overview of technological trends

The recent development in communications technologies including the voice-over IP issues continue to open a range of opportunities to improve the real-time sharing of information, and enabling faster decisions. The KSA will continue to drive the exploitation of such technologies, not only creating a water information hub, but a water information hub of the digital era.

Document management systems linked to workflow are still a high-priority consideration for this KSA. Recent developments have rendered these systems highly reliable. Whilst this was identified much earlier as a priority development, it had to wait for the completion of the FMS. In 2007/08, it will be implemented.

Key stakeholders

Creation, transfer and dissemination of knowledge require an appropriate knowledge user base, that is water-related experts, practitioners, academics, science councils, the government (at all levels) and other research organisations. The WRC has to be able to effectively translate needs into research ideas and further transfer research results and new technologies to end-users or end-user representatives and communities.

Research managers and staff of the WRC

Implementing the FMS to facilitate decision making, especially with respect to research project management, will continue. Staff members need to be able to access the information base of the organisation and be empowered to take decisive action.

The KSA shall continue in the belief that the overarching need is to develop one seamless system for employees to conduct its business. The FMS system will be further developed and enhanced to support this function.

External customers

The level of knowledge of water-centred knowledge management in the communities in general is limited and that position has not changed much. The following issues are still considered high priority even for 2007/08:

- Improvement of public understanding of water issues
- Effective dissemination and sharing of information
- Being the real hub for water information
- Improving the efficiency of downloading information from the WRC's webpage.

External stakeholders are government departments, with emphasis on DWAF, local government and municipal officers, private service providers, decision makers and policy-makers. At every stage of knowledge accumulation, the above-mentioned category of knowledge users is almost always the main target group. It is important that the 'knowledge workers' in this sector make their decisions by increasing the amount of relevant information they have access to, introducing the elements of expertise and experience through collaboration capabilities and shortening the time it takes to make better decisions.

Other stakeholders and user communities

These include water boards, municipalities, community associations, development groups, consultants, etc. Encouraging free flow of information fosters innovation, and in today's information-driven economy, organisations may uncover the most opportunities, and ultimately derive most value from intellectual assets. Knowledge sharing must serve as the foundation for collaboration.

Researchers and service providers

The ongoing reassessment of key assumptions, renewal of existing knowledge, creation of new knowledge and its application, requires that the knowledge available at a certain point in time and context be accessible.

Communities and general public

South Africa cannot change to sustainable water management without community cooperation and the latter cannot cooperate if they do not understand. The basis for understanding is knowledge. The water sector in general also faces the challenge of being able to link up and work globally and regionally.

Other players

A number of national and international organisations work in collaboration with the WRC and in some cases formal agreements exist. These include the following as examples:

- American Water Works Association Research Foundation (AWWRF)
- International Water Association (IWA)
- Water Research Foundation (WRF)
- International Water Management Institute (IWMI)
- Water and Sanitation Collaborative Council (WSSCC), etc.
- France (IRD, CIRAD and CNRS)
- DST bilateral cooperation programmes.

Stakeholder relations

Sourcing and appropriate use of novel corporate gifts

The KSA has distributed a USB multi-socket with the WRC logo on as thanks to reviewers for their input into the research cycle.

Effective interaction with media

The WRC formulated and introduced a media policy to members of the Executive as well as research managers. The rationale of introducing such a policy was to equip potential media spokespersons with a guideline document on how to handle media matters. The process of finalising a media strategy has commenced and is expected to be completed by April 2008. The purpose of such a strategy is to educate journalists and to encourage balanced and accurate reporting. The following are instances of media coverage about WRC activities:

- The WRC coordinated a site visit to the Kruger National Park in January. The outcome of this site visit was a documentary on fish ladders on the SABC 2 Programme *50/50*. The fish-ladder project was funded largely by the WRC and the WRC was mentioned several times on the programme.
- The research project on EDCs at the Rietvlei Dam proved to be highly controversial. Media personnel inundated the WRC with queries and questions. The WRC media officer informed journalists, including the journalist from the *Mail&Guardian*, that the research report on EDCs was not yet ready for publication. However, the journalist from the *Mail&Guardian* went ahead and published sensationalist material on the topic, without giving the balanced view. The WRC submitted a detailed response, outlining discrepancies and correcting misleading information which was published in the *Mail&Guardian* the following week.
- During September *Die Beeld* published articles on EDC contamination at Rietvlei Nature Reserve which contained some inaccuracies. The WRC counteracted by issuing a media release and correcting inaccuracies and inconsistencies.
- A WRC Director gave a radio interview for the South African Agency for Science and Technology

Advancement (SAASTA) initiative during which he addressed students at the University of Pretoria. The initiative focused on role models in the science and technology field. The Director involved has extensive experience in the field of ecosystems and provided students with a comprehensive background to his career.

- Coinciding with the launch of the publication, *Our Water Our Culture: A Glimpse into the Water History of the South African People*, a media release was issued and members of the media were invited to the launch. *Die Beeld* published an article outlining the launch of the publication. On 27 February a staff member was interviewed on *Eastern Mosaic*, a cultural programme on SABC 2, on the publication.
- The WRC enjoyed favourable press coverage on the Wastewater Conference that was held in East London. The *Daily Dispatch*, *Die Burger* and *Die Beeld* covered the event.

STRATEGIC INITIATIVES

National initiatives

Stakeholder map

A comprehensive stakeholder map has been developed for the WRC. The stakeholder map for each KSA and the WRC as a whole includes the level of interaction, defines the relationship, the stakeholders' needs and expectations as well as the planned communication and relationship plan.

Leadership

The Director of the KSA was elected as the Vice-President of the Water Institute of Southern Africa and chairs the WISA Education, Training and Capacity Building Portfolio Committee.

The WRC through the KSA Director is represented on the National Advisory Forum for the Development of South Africa's National Programme of Action for the Protection of the Marine Environment from Land Based Activity led by the Department of Environmental Affairs and Tourism (DEAT).

Strategic national initiatives

Department of Water Affairs and Forestry

The WRC continues to strengthen communication and coordination with DWAF, through institutionalising interaction in a formal senior management committee which will meet bi-monthly to exchange information and coordinate activities.

An implementing agent agreement was concluded between the WRC and the DWAF represented by Harrison Pienaar in his capacity as Acting Deputy Director-General: Policy and Regulation.

On 7 March 2008 the WRC hosted an Open Day for DWAF, aimed at strengthening synergy between DWAF and the WRC. Mr Helgard Muller addressed the delegates on behalf of DWAF. More than 60 DWAF officials attended this event and the feedback from them has been very positive.

Other government departments

The WRC was represented by a staff member (who also delivered a presentation) at the DST workshop on Technology-Based Solutions for Accelerated Delivery of Water Services which was held in Boksburg on 23 November 2007. The event was attended by the Deputy Minister of the Department of Science and Technology, Mr D Hanekom.

General

The KSA supported the various national initiatives as rolled out by the other KSAs as reflected in the CEO report – this includes the development of custom material for exhibitions and events, production of banners, exhibitions, etc.

African initiatives

- The WRC (on request from The Department of Science and Technology) hosted a Kenyan delegation on 6 September 2007 where water resource management issues and future collaborations were discussed. The Kenya Water Institute, a training institute for water sector professionals, was also represented. The knowledge exchange was mutually beneficial
- The WRC continues to support NEPAD – Office of Science Technology Development
- The KSA Director is also on the Board of the Water Research Fund of Southern Africa (WARFSA)
- The WRC aims to actively participate in the African Water Week organised by the African Water Ministers and AfDB
- KSA 5 (with KSA 3) has also initiated the development of a *Situational Report on Wastewater Sludge and Faecal Sludge Management* for all African countries in collaboration with the UCLGA.

International player

The KSA participated in a number of global initiatives:

- The KSA Director was invited to prepare the South African contribution to the *Global Atlas for Wastewater Sludge Management* in association with the IWA Sludge Management Specialist Group and WHO.
- The KSA Director was a member of the international programme committee for the IWA conference entitled: 'Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial and Public Synergy' held on 24-28 June 2007 in Moncton, New Brunswick, Canada. The conference was attended by 450 delegates and 44 countries were represented. The KSA Director presented an invited plenary address entitled: 'Management of wastewater and faecal sludge in Southern Africa.'

GROWING THE KNOWLEDGE BASE

Capacity building

The WRC has compiled a comprehensive database of students supported by the research portfolio. The database records comprehensive details (including student name, country of origin, race, gender, qualification pursued/achieved, and institution).

The KSA has developed a working relationship with Sci-Bono and was instrumental in developing the youth programme for the water week 2008 and the launch of the lesson plans at this event.

WRC continues to be part of the *Women in Water, Sanitation and Forestry Awards*. Dr Sue Hart was nominated and awarded a special category of lifetime achiever. She is the founder of the environmental NGO, EcoLink.

The following sponsorships will be given for 2007/08:

- Mvula diary advertisement
- NSTF awards dinner
- SA Youth Water Prize
- *Local Government Handbook*
- WISA Directory.

HIGHLIGHTS FOR THE 2007/08 FINANCIAL YEAR IN TERMS OF THRUSTS

THRUST 1: RESEARCH COORDINATION AND STRATEGIC RESEARCH ADVICE

Fund Management System (FMS)

The FMS was implemented in 2006 and has now entered the 3rd round. It has only now entered the phase of integrated testing with a populated database. In this year, all the data were transferred from Oracle to Enterprize DB. The following will be achieved in 2008/09:

- Enhance the level of competency of users (especially coordinators)
- Capture all projects on the business plan in the current status on the FMS
- Debug the system to ensure functionality to design specifications
- Once the data are captured and the system effectively debugged, the management report facility will be tested and assessed
- Structure enhancements and run them on the test server to be implemented in the research cycle starting in 2009
- Streamline the proposal cycle with greater web interface efficiency.

Business excellence drive

Research cycle
The KSA will continue to coordinate the technical and financial finalisation of reports in the research cycle.

Improvements will include:
- Finalisation and finalisation data reports
- Development of templates for project-related documents such as a final reports, minutes, agendas, etc.
- Review of upgraded project leader guidelines for proposals and projects on the web
- Develop a *Research Manager Guide* for the WRC.

THRUST 2: KNOWLEDGE DISSEMINATION AND PROMOTION

Conferences, exhibitions and workshops

KSA 5 contributed to the following events:

The WRC and WIN-SA participated and exhibited at the AfricaSan 2008 Conference on 18-20 February 2008 in Durban.

The WRC exhibited at the Water Management Excellence Conference, 15-17 August 2007, *Sandton Convention Centre*. It was a collaborative project between DWAF, the WRC and WISA which aimed to assist the water sector with its current drive to ensure a turn-around in service delivery. The WRC hosted the wastewater management conference train led by the KSA Director who also presented a paper. The WRC also exhibited at this conference and WRC reports and publications were on display.

The SANCHIAS Symposium was held on 6 to 7 September 2007 in Cape Town. A total of 116 delegates attended the 2-day conference where 69 papers were delivered over 21 sessions and covered topics across the water resources spectrum. The event provided engineers, scientists and managers in the hydrology field the opportunity to network and participate in discussion forums relating to the latest research trends and developments. The WRC was a major sponsor: Graduate participation support was provided (R12 000) as well as sponsorship of prizes for the 1st, 2nd and 3rd best symposium papers (R4 200 in total). The WRC also exhibited at this event and various WRC publications were made available.

Approximately 254 delegates from across South Africa and internationally registered for the 3-day South African Biennial Groundwater Conference that was held from 8 to 10 October 2007 at *Ilanga Estates* in Bloemfontein. This conference of the Groundwater Division of the Geological Society of South Africa draws groundwater practitioners, researchers, regulators and other interested parties from across South Africa, Africa, Europe, Asia and North America. The WRC exhibited at this event and WRC reports and publications proved to be popular.

The IMESA Conference was held in KwaZulu-Natal, at the *International Convention Centre* in Durban, from 23 to 26 October 2007. The Institute of Municipal Engineering of Southern Africa represents approximately 600 engineering practitioners in the municipal engineering field. The WRC exhibited at this event and WRC reports and publications proved to be popular.

The International Commission on Irrigation and Drainage (ICID) 2nd African Regional Conference, 6-9 November 2007, Krugersdorp event was hosted jointly by the WRC and the national Department of Agriculture. A call for papers was widely publicised and 65 abstracts were received from different countries in Africa. Reviewers from the four regions of Africa (Southern, Eastern, Western and Central (ARID) and Northern) were identified and the abstracts were forwarded to them for their consideration. Keynote speakers from the 4 regions and a main keynote speaker from the World Bank were also identified and contacted.

The UNESCO HELP Symposium was held from 4 to 9 November at *Emperor's Palace*, Johannesburg. The WRC, together with DWAF and WISA, hosted the HELP Symposium during 2007. This is a major UNESCO Conference to be held in South Africa. The conference was attended by approximately 180 water scientists as well as policy and law experts from over 25 countries. The conference was hosted by the WRC, DWAF, WISA, IWMI, and UKZN. The WRC was one of the exhibitors at this high-profile event and WRC reports were received favourably.

The WRC exhibited at the International Conference on Integrated Water Resource Management (IWRM), 10-12 March 2008, at the Cape Town *International Convention Centre*. The conference was hosted by the WRC of South Africa in partnership with DWAF and WISA. This conference was a platform to celebrate the 10th anniversary of South Africa's National Water Act (NWA) as well as using the Conference as an opportunity to hold the 2nd IHP meeting. Approximately 180 delegates from across South Africa and internationally registered for the 2-day conference and 40 delegates registered for the IHP meeting.

The WRC coordinated a UNEP Workshop on Vulnerability held at the *Farm Inn* on 23 July 2007, where five representatives of five African sub-regions attended. The WRC led the South African region and was tasked to assess the quality of the report (by collating, editing, and printing).

The European Union's 7th Framework Programme for Research and Technological Development (FP7) was launched at the beginning of 2007. This funding programme will run for 7 years, with a total budget of over €50 bn. The WRC coordinated this initiative and held workshops:
- The FP7 Workshop held on 15-16 November 2007 in Dakar, Senegal (representing the Western region of Africa)
- The FP7 Workshop held on 27-30 November in Nairobi, Kenya (representing the Eastern region).

KSA 5 made all the necessary arrangements including financial, economy flights, accommodation, etc. for the meeting in Dakar, Senegal and Nairobi, Kenya.

Public appreciation

Citations
The following citations were noted with respect to KSA activities and participation in various initiatives:
- At least 4 citations on the quality and standard of *Water SA* with specific appreciation for the fact that the table of content now accompanies the electronic alert
- At least 12 citations of appreciation from international stakeholders for the Vulnerability Workshop in RSA on 23-25 July 2007, *Farm Inn*, Pretoria; FP7 workshop in Dakar, Senegal, 15-16 November 2007; and FP7 workshop in Nairobi, Kenya, 28-30 November 2007
- At least 14 citations of appreciation from internal and national stakeholders for the KSA's involvement in the WRC Internal Open Day, Hartbeespoort Dam, 20 September 2007; launch of *Our Water Our Culture: A Glimpse into South Africa's Water History*: 11 October 2007; and the Portfolio Committee, October 2007
- Independent on-line media report 10 December 2007 – water recycling – pipe colour coding
- 'I am very impressed with the Grade 3 activities. I shall be including them in our lesson preparation when we cover water,' Ms Lynne Greef, Educator – Rietondale Primary School, Pretoria, in response to the science lesson plans published by the WRC, February 2008
- At least 5 citations on the findings of the WRC/DWAF collaborative status quo investigation of wastewater treatment plants in South Africa.

THRUST 3: PUBLICATIONS
The WRC published a coffee-table edition of a book titled *Our Water Our Culture: A Glimpse into South Africa's Water History*. The publication emphasises the importance of water in sustaining the rich cultural diversity of the South African people. The publication was launched at a gala event on 11 October 2007 at the *CSIR Convention Centre*. The Minister of Water Affairs and Forestry, Ms Lindiwe

Hendricks, officially launched the book. At the request of the Minister, 100 copies of the book were sent to the Minister who distributed them to members of Parliament (including members of the Portfolio Committee on Water Affairs and Forestry).

A special edition of *Water SA* (Vol 33 No 3) was produced in May 2007 and published in June 2007, with the theme: The Nutritional Value and Water Use of Indigenous Crops for Improved Livelihoods.

WRC publications

A continuously updated list of WRC publications is posted on our website (www.wrc.org.za) for perusal by users and orders for reports may be placed either electronically, telephonically or by fax.
An effective marketing strategy for the knowledge assets was developed. A report catalogue of selected TT reports has been compiled, is continuously updated and is being widely distributed. During the year under review 108 new reports were published and 26 519 reports were dispatched upon request from stakeholders; some of these were sold and the income generated in this way came to R103 380.

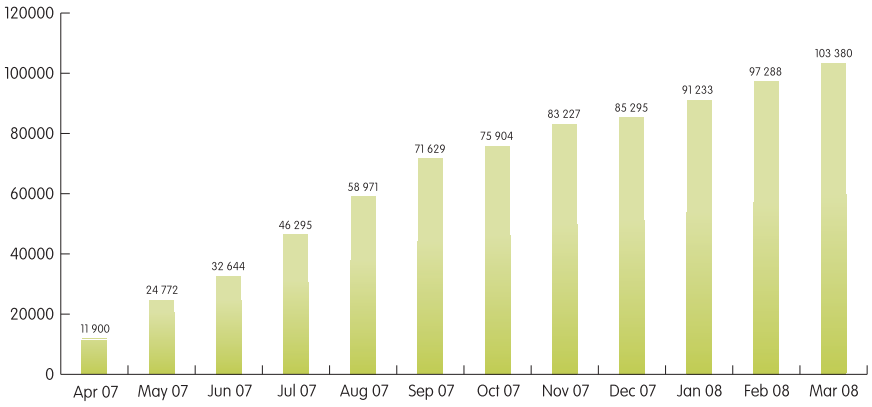
WRC reports distributed to our stakeholders during 2007

Board	1
FWR	185
Institute	9 237
Municipality	930
Private	10 426
School	88
State Library	600
Technikon	1 239
University	2 649
WRC	1 164
Grand Total:	**26 519**

MOST POPULAR REPORTS DISTRIBUTED DURING 2007

REPORT NUMBER	KSA	TITLE OF REPORT	TOTALS
TT261/06	3	Guidelines for the Utilisation and Disposal of Wastewater sludge: **Volume 1** of **5**: Selection of Management Options	690
TT 262/06	3	Guidelines for the Utilisation and Disposal of Wastewater Sludge: **Volume 2** of **5**: Requirements for the Agricultural Use of Wastewater Sludge	660
TT 265/06	3	Handbook for Waterworks Operation	551
TT 247/05	3	An Illustrated Guide to Basic Water Purification Operations	540
TT 300/07	3	An Assessment of Non-Revenue Water in South Africa	505
TT 266/06	3	A Desalination Guide for South African Municipal Engineers	492
TT 316/07	3	Water Services and HIV/AIDS; Integrating Health and Hygiene Education in the Water and Sanitation Sector in the Context of HIV/AIDS	412
TT 317/07	3	Water Services and HIV/AIDS: A Guide for Local Government Councilors and Officials Responsible for Water, Sanitation and Municipal Health Services	351
TT 294/07	2	Estuaries and Integrated Development Planning: A Managers' Guide	2575
TT 302/07	2	The State of Yellowfish Report in South Africa (Selling price R50-00)	1081
TT 307/07	2	Watermark: The Lasting Impression of the Ecological Reserve	969
TT 321/07	2	WET- RoadMap: A Guide to the Wetland Management Series	265
TT 303/07	1	Groundwater Sampling: A Comprehensive Guide for Sampling Methods: Second edition	286

Cumulative sales of reports for 2007/08



THRUST 4: INTELLECTUAL PROPERTY MANAGEMENT

The WRC continues to see growth in its patent portfolio. In 2007 5 South African complete applications were filed, one ARIPO and one PCT application.

The applications referred to above are based on the following provisional applications filed in 2006 and 2007:

- Biosensor
- Method of detecting the presence of micro-organisms in a solution
- Olive wastewater treatment
- Passive sampler
- Application for ash and its derivatives
- Synthesis of zeolites
- Treatment of wastewater using dual-stage membrane bioreactor.

The aforementioned applications are still under prosecution and not yet completed. We hope to receive certificate of grant for all SA applications in mid-2008. The PCT application entitled: 'Treatment of wastewater using dual-stage membrane bioreactor' was filed in January 2008.

Assignments

- The olive wastewater treatment technology was assigned to the University of Cape Town (UCT) and a benefit-sharing agreement was duly signed. Following the aforementioned benefit agreement an option agreement was concluded in terms of which Dr Garcin was granted an exclusive option to enter into a licensing agreement for commercial development and public utilisation, should its evaluation so warrant.

- The WRC portion of the Petro™ patent has been assigned to Mr Meiring, the co-owner.

Commercialised technologies

The following patents are currently licensed:

- The BioSURE™ process, a cluster of 36 patents, is licensed to ERWAT. The BioSURE™ process is still undergoing further development.
- The Secondary Metabolites, a cluster of 13 patents, are currently licensed to Synexa-Life Sciences and we have been receiving royalties since 2006. We expect better royalty payment in 2008 since their report shows an improvement in their sales. To date our royalties are in the region of R24 000.
- South African Capillary Ultrafiltration Membrane Technology (SACUF), a cluster of 5 patents was licensed to Ikusasa Chemicals in January 2008.
- The ambient temperature ferrite process (ATFP) for removing iron from acid mine drainage is currently licensed to Environmental Technology Agencies (ETA).

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IMPACT AREAS

The core strategy of the WRC requires a number of key cross-cutting issues of national importance to be addressed. Each of the KSAs, through its own portfolio of thrusts and programmes, makes an important contribution to addressing these issues. However, to ensure that the WRC research portfolio as a whole achieves the desired impact with regard to each of these key strategic issues, they are dealt with specifically in 4 Impact Areas established purposely to provide for the necessary integration and leadership roles and functions. The 4 Impact Areas are directly linked to DWAF's overarching objective of economic growth and sustainability. The areas address the principles for Water for Sustainable Growth and Development. Apart from being of national importance, the issues addressed by the Impact Areas are of regional and international priority, as the agendas of major events and movements such as the WSSD, successive meetings of the World Water Forum as well as NEPAD have clearly shown.

The integrating function of the Impact Areas entails drawing together programmes and projects which address the relevant cross-cutting issues and which are under way within the portfolios of each of the KSAs. Leadership and support is also provided for new KSA initiatives which can further knowledge with regard to Impact Area-related strategic thrusts. The domains may also drive specific programmes/projects that are overarching and relate to all KSAs in a general manner.

The Impact Areas address the following key issues:

- Water and Society
- Water and the Economy
- Water and the Environment
- Water and Health

WATER AND SOCIETY

Dr Andrew Sanewe | Head |

SCOPE

The **Water and Society Impact Area** has undergone a strategic review during 2006/07 and as a result changes to the scope, objectives and thrusts have been implemented.

The Impact Area of water and society seeks to build understanding of the social aspects and dynamics of water in society and the role water can play in achieving social transformation and justice. It does so in the context of deepening democratic practices, the extension of water services and redressing the wrongs of the past, as well as a commitment to ecological sustainability while facing growing pressure on water resources, the effects of climate change, HIV/AIDS and the daily realities of households living in poverty. It ensures that a social perspective is brought to bear on all aspects of water research. It is sensitive to multiple perspectives, including those of gender, class, disability, urban or rural, culture and religion. It aims to integrate a variety of methodologies to provide a holistic view. It emphasises respect for people's rights and encourages participation in monitoring and decision-making as entrenched in the country's Constitution.

OBJECTIVES

This Impact Area will support research which:

- Develops a greater understanding of social dynamics in the water sector, and people's needs for and views of water; encourages people's participation in water management and decisions about water.
- Searches for ways of using water for transformation and social justice.
- Enables water users at all scales and in different localities to meet the challenges of utilising water as a shared and scarce resource in a sustainable way.
- Provides water services which are socially acceptable, affordable and available to all.
- Ensures ready access to water for the poor and disadvantaged members of society.

THRUSTS

THRUST 1: COOPERATIVE GOVERNANCE

In the context of a growing confidence in the instruments of democracy and participation, this thrust focuses on strengthening and encouraging relevant and affected stakeholders in the water

sector to agree and work towards achieving common goals. It promotes a governance system that includes all sectors of society, namely government organisations, non-government organisations, private sector and civil society. It focuses on developing an understanding of the opportunities for citizens to participate and influence decisions about water management. It assesses how the roles and participation of different stakeholders in water planning, the regulation of the water sector, monitoring and evaluation of the impact of service delivery can be strengthened and encouraged.

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

South Africa's water policy and legislation reflects a deep commitment to social transformation and justice. This thrust will investigate the possibilities for using water to redress the injustices of the past and to bring about a more just society. It will study the options for the reallocation of water for transformation and equity purposes, both on national and community scales. It will also investigate the extent to which gender, age and physical disability influence access to water resources.

THRUST 3: SUSTAINABLE USE OF WATER AS A SCARCE AND SHARED RESOURCE

This thrust develops an understanding of different aspects of water scarcity in the context of enhancing sustainability of water systems. It will focus on investigating hydro-political issues at a local, national and regional scale. It addresses the dimensions and causes of scarcity of water in our society which include the inter-sectoral and transboundary sharing of water, water scarcity in relation to demand, water quality, and the roles of water in various economic and societal sectors. It investigates the social impacts of climate change on water resources and water supply systems. Appropriate research initiatives will aim at alleviating the impacts of scarcity and degraded water quality on society and the water environment, thereby reducing the potential for conflict, and promoting healthy cooperation with regard to integrated, sustainable management. Research in this thrust will support policy and decision-making regarding the allocation of water (over and above the Reserve) between competing groups, namely domestic, industrial and agricultural.

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

The focus of this thrust remains on analysing and understanding society's needs for water services. This will lead to guidelines aimed at enhancing utilisation of limited water resources and finance in sustainable service provision. Such understanding will ensure that the real needs of society are known and addressed in a flexible and socially acceptable manner. Issues around institutional arrangements, hygiene and sanitation will be investigated.

THRUST 5: POVERTY ALLEVIATION

The focus of research within this thrust remains the linkages between water and poverty. This will lead to effective strategies for using water resources to break the poverty cycle and to promote food security.

Research portfolio

The funding for research projects supported by the various KSAs and focusing on this Impact Area, is estimated at about R13.9 million for 2007/08 (R3.6 million more than in 2006/07). Of this, approximately R8.3 million is for ongoing research. Although spending on new projects in this Impact Area progressively declined from R6.3 million in 2004/05 to R3.2 million in 2005/06 and R2.8 million in 2006/07, in 2007/08 new project expenditure doubled to R5.6 million. Total expenditure on water and society related projects will continue to increase to over R15 million in 2008/09.

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

Education, awareness and behaviour change requirements to improve safe water practices
Human Sciences Research Council
No 1522

Regulation in a democratic society cannot work independently of participation by citizens. Public agencies acting as regulators have to have the views of citizens to hand as it is their interests which are being protected. As the regulatory strategy in South Africa acknowledges, without this knowledge, regulation will have a limited impact. Internationally there is increasing interest in engaging poor communities and capturing citizen voice in scorecards as a step towards improving accountability between citizen and provider. Such participation should assist developing the regulatory framework in South Africa as communities understand the operation and standards of water services, voice their needs, and, as necessary, seek redress. The expression of voice is an integral aspect of a developed reflexive delivery system in which community voice operates as an important prod to municipalities acting as Water Service Authorities to respond to expressed need. Although greater attention to citizen voice is advocated, the challenge remains as to what method can be adopted to involve poor communities on the widest basis actively in people's regulation of water services?

The project has succeeded in providing a set of tools for community appraisal and engagement with the evolving regulatory system. New tools appropriate to the situation have been developed and existing community tools reshaped. These tools and community materials on water services are supported by an established training programme and strategy for spreading their use and techniques. The methods and materials have been developed in deprived and remote communities with the greatest challenges in water services and the tools have been shown to add data and value to community advocacy for better services.

Cost: R1 266 000
Term: 2004-2007

The state of community consultation in the provision of water services
Sigodi Marah Martin
No 1616

Community consultation in the provision of water services is both a legislative obligation and a critical success factor. No single comprehensive study has been done which provides a barometer of the general public's knowledge and understanding of the water services messages as communicated, and their involvement in, and preferences for, consultative processes. For the purpose of this study, the term 'community consultation' was broadly defined to include all types of communication aimed at the general public, ranging from information dissemination to community participation. The study limited itself to water services messages and it focuses on two major communication campaigns of DWAF that have dealt specifically with Water Services, Free Basic Water and Water and Sanitation Hygiene (WASH).

The 5 key water services knowledge areas were identified (Free Basic Water; Basic Water as a Constitutional Right; Responsibilities; Health and Hygiene; and Institutional Roles) and the knowledge and understanding of South Africans were established via a quantitative survey. The results were presented using a 'barometer' instrument. The results showed that 'Responsibilities' scored higher than 'Rights', i.e. people have better knowledge of their responsibilities than their rights. South Africans seem to be at least aware of their responsibility to pay for water in excess of 6 000 litres/month and to report broken infrastructure that directly affects them. This is also the case with answers on Health and Hygiene received from respondents. South African adults scored the lowest in the areas Free Basic Water and Constitutional Rights, because 59% said that they have never heard of Free Basic Water and

45% said they have never heard of the Constitution. The study also highlighted that more focused interpersonal interventions are necessary to bring rural consumers on par with urban consumers. These would include meetings, community development workers/municipal development officials, community networks, community media and tribal messengers. South Africans cannot exercise their constitutional rights if they have never heard of the Constitution.

Cost: R700 000
Term: 2005-2007

THRUST 5: POVERTY ALLEVIATION

Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research, Limpopo Province
Tshwane University of Technology
No 1464

The overall objective of the project was to develop and implement technologies and knowledge useful for farmers in order to improve rural livelihoods. Two types of research and development activities were conducted, namely initiatives aimed at understanding management practices and initiatives aimed at improving management activities. Methods used in data collection at Dzindi included:

- The use of Rapid Rural Appraisal (RRA) techniques
- Surveys involving probability sampling and structured interview schedules
- Experiments in the green house, on-station and on-farm
- Qualitative methods.

Methods of data collection at Khumbe and Rabali were largely limited to the use of RRA techniques.

The analysis of livelihood and farming of plot holder households revealed that for the purposes of developing best management practices, the 'one size fits all' perspective is not valid. At individual farm level best management practices need to be tailored to the objective of the farmer and the role of farming in the overall livelihood strategy of the household. The development of livelihood types, farming styles and the relationship between farming and overall livelihood were shown to be useful approaches to make sense of the diversity that was observed. The study of the social and institutional domains of Dzindi showed that there was considerable room to improve the management of shared resources. On smallholder canal irrigation schemes, the sharing of water and the maintenance of the irrigation infrastructure influence the availability of water for irrigation at the plots. Collaboration among farmers, or the lack thereof, also affects access to markets. However, the study found that state intervention (through the compulsory introduction of the co-operative model) in arenas where smallholders successfully operate their own organisations should either be avoided completely or be done in ways that allow smallholders sufficient time to internalise the new concepts and adapt them to suit their own circumstances. Land tenure and farmers' interpretation of the prevailing tenure system influence land exchange among farmers, which is important for farmers seeking to expand their operations. Collaboration among farmers is also important in terms of access to land preparation services. Research and development activities aimed at improving management practices focused on production aspects and included the integration of crop and animal production systems, improvement of the production of selected indigenous crops (African leafy vegetables) and the improvement of green maize production.

Cost: R1 200 000
Term: 2003-2007

CURRENT

THRUST 1: COOPERATIVE GOVERNANCE

The development of a framework for the involvement of local government in water resource management linked to water service provision
Rhodes University
No 1688

Institutional arrangements supporting the implementation of the National Water Act (36 of 1998) and the Water Services Act (108 of 1997) are devolved across all three tiers of government. At a regional level, water resource management (WRM) is currently being transferred from regional DWAF offices to catchment management agencies (CMAs), facilitated by water user associations (WUAs) with additional stakeholder input from catchment forums including local government. Water services authorities (WSAs) are to manage water service provision (WSP); local authorities can act as WSAs. Challenges to local government are therefore considerable, particularly where capacity and financial resources are limited. Added challenges are posed by municipal and water management area boundaries that do not coincide; the inattention to the linkages required for sustainable WRM to support WSP; and little guidance given to the links between WUAs, catchment forums and local government. This project emerges from the recent call for researchers' participation in the design of Integrated WRM (IWRM) institutional arrangements research programme. Local government needs to establish WSP within an IWRM, in an environmentally sustainable manner. In order for local governments to effectively contribute to catchment WRM, understanding point and non-point source management, with questions of water quality and quantity impacts on resource management, is essential.

Estimated cost: R537 000
Expected term: 2006-2009

A philosophy and strategy enabling learning for good ecosystem governance
CSIR
No 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. In addition, the aim is also to develop a strategy and implement it using the above principles in pilot areas. As a new emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200
Expected term: 2006-2009

Institutional dimensions of water resource management in South Africa: Socio-cultural perspectives
University of Cape Town
No 1698

This project seeks to analyse, monitor and evaluate the new water management institutional arrangements by focusing on the role of socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices in determining water management outcomes. Some of the long-term benefits of the research include enhancing public participation in water management and the voices of local people, alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400
Expected term: 2006-2009

Enriching freshwater conservation planning and management
CSIR Environmentek
No 1678

The pressures from social-economic aspirations have resulted in a progressive degradation of freshwater habitats in recent decades. As in other countries, this country's rivers have deteriorated faster than terrestrial habitats. Ad hoc conservation efforts are

not effective in the face of this pressure; a strategic and systematic approach is needed if the initiative is to be effective.

This project is part of a suite of initiatives (funded by WRC, DWAF and CSIR) which include the development of cross-sectoral policy and planning tools for conservation planning, and aims to advance our understanding of the relationships between freshwater conservation planning and the socio-economic and political processes that govern freshwater conservation at international, national and sub-national levels. This will be done through engaging the broader socio-economic and political discourse to identify the issues that are important for the successful implementation of the conservation planning process, and incorporating these into the overall process. This will be tested in a specific geographic context.

Cost: R450 000
Term: 2006-2008

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector
Council for Geoscience
No 1612

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made. This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralisation of services. Are these new arrangements supporting gender mainstreaming? This is what the study will be highlighting.

Estimated cost: R600 000
Expected term: 2005-2007

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas
Umgeni Water
No 1610

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and proven, which would then allow piloting and implementation much more attractive. The concepts will contribute to wider participation of small-scale entrepreneurs in the management of water services.

Estimated cost: R600 000
Expected term: 2005-2007

Sustainable options for community level management of grey-water in settlements without on-site waterborne sanitation
University of Cape Town, Department of Civil Engineering
No 1654

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects, which influences the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be possible for extension to the rest of South Africa. This will be supported by preparation of education material for community level training concerning grey-water management options and techniques.

Estimated cost: R750 000
Expected term: 2006-2009

Review of regulatory aspects of the water services sector
AWI
No 1667

The changing water services institutional and legislative environment in South Africa has indicated the need for a strong and competent regulatory component to oversee the activities of the sector, such that objectives of sustainability, equity and efficiency are achieved and maintained. There had been many debates and discussions on this topic area, as to whether the regulatory function should be an independent function or whether the sector can afford a regulatory function and who will finance such an initiative, etc. DWAF has commissioned a number of studies in this regard, to address many of these queries and questions which have emerged. However, the subject area is very new to the sector and there is a great deal of information requirements to support decision making and input to support this regulatory function. The area also poses many challenges in its implementation. The study aims to support and build on national initiatives to find optimum models and mechanisms for effective regulation of the water services sector. The study will cover:

- Review of international models for water services sector regulation and highlight pros and cons of the different regulatory models
- Assessment of institutional and human capacity required to implement sector regulation
- Evaluation of the cost implication of sector regulation on municipalities
- Exploration of the feasibility of using incentives to regulate the water services sector
- Investigate international best practice on proper regulation, identifying institutional, financial and operating procedures of relevance to South Africa
- Investigating and evaluating case studies of independent regulation and central regulation, capturing lessons and experiences of relevance to the South African situation
- Investigate water sector and consumer opinion on independent vs. central regulation and aspects that should be addressed
- Determine the scope of water services regulation and the linkage/integration with water resource management
- Identify the capacity and competency requirements to facilitate regulation across the sector
- Evaluation of the cost implication of water sector regulation and its impact on tariffs/chain of costs
- Exploration of the feasibility of using incentives to regulate the water services sector.

Estimated cost: R800 000
Expected term: 2006-2008

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa
Johannesburg University of Technology
No 1700

Over the years, the government has spent billions of rand to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a

standard methodology to quantify the benefits (social, technical, health, economic and environmental). Thus, the time is most appropriate for a study of this nature.

Estimated cost: R1 200 000
Expected term: 2006-2008

THRUST 5: POVERTY ALLEVIATION

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province
Zakhe Agricultural College
No 1465

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exerts even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention should be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods should be analysed.

Estimated cost: R3 000 000
Expected term: 2003-2009

Best management practices for smallholder farming on two irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research
University of Fort Hare
No 1477

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. The research project on 'best management practices for small-scale subsistence farming' therefore requires commitment and cooperation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000
Expected term: 2004-2009

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province
University of Fort Hare
No 1478

Approximately 74% of South Africa's rain-water is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 000 000
Expected term: 2004-2009

Agro-forestry systems for improved food production through the efficient use of water
Environmentek, CSIR
No 1480

Less than 15% of land area in South Africa is arable. This implies that there is very limited scope for conventional food production, both on irrigated and dry-land. In addition to limited arable land, South Africa is a water-scarce country. Its rainfall is below the world average, and its distribution is somewhat unreliable.

The relatively low rainfall and limited arable land make it imperative to effectively and efficiently use these natural resources for food and fibre production. This is even more important for emerging and subsistence farmers who often lack access to information and use of production technologies.

Smallholder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands.

In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor.

This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally. Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa.

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment.

Estimated cost: R3 250 000
Expected term: 2004-2009

Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods
Rural Integrated Engineering (Pty) Ltd
No 1575

The rural landscape of South Africa is characterised by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Expected cost: R2 750 000
Estimated term: 2005-2009

Real-time irrigation advice for small-scale sugar-cane production using a crop model, weather data and cellular communication
SASRI
No 1576

Water use efficiency in irrigated sugar-cane agriculture is notoriously low and could be increased dramatically if farmers applied established scheduling methods. A recent survey showed that 70% of sugar-cane farmers use dragline irrigation and that 50% of these use fixed irrigation schedules. This leads to severe over-irrigation in times of low water demand and impacts negatively on the profitability of irrigated sugar-cane production and on the environment. Pressure is also building for water users to demonstrate efficient use of the scarce and sought-after resource. The main reasons for non-adoption of scheduling technology as determined from a survey that was conducted were:

- The complexity of technology in relation to practical constraints on the farm
- An under-estimation of the benefits of accurate scheduling. This applies especially to small-scale growers who do not have access to computers, the Internet or expensive equipment.

The challenge therefore is to provide simple, practical and useful advice to farmers using state of the art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. The Agronomy Department at SASRI has developed a prototype of a system (called *My Canesim*) consisting of the following: Weather data recorded by automatic weather stations and remotely downloaded daily through the cellular network; A web-based simulation model that suggests irrigation actions; An Internet-based user interface for advisors and extension staff to enter field, crop and irrigation system data and to view simulation results; The automatic distribution of irrigation on/off advice in isiZulu through SMS technology to farmers' cellular phones. In a pilot case study, the system was implemented in 2004 on a limited scale in Pongola. Irrigation advice is provided to six small-scale growers and its impact monitored. Initial results are very promising and indications are that water savings of 30% and cost reduction of R1 400/ha could be achieved for small-scale growers. There is enough evidence to push for wider implementation of this service. These direct benefits are possible on 8 000 ha to more than 1 500 small-scale farmers in Pongola, the Makatini flats, and the Komati area. The technology could also be used by commercial growers on 56 000 ha. Indirect environmental benefits are reduced water extraction from river systems, and reduced runoff, deep drainage and water pollution.

Estimated cost: R256 000
Expected term: 2005-2008

Nutritional value and water use of indigenous crops for improved rural livelihoods
University of Pretoria, Centre for Nutrition
No 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (WRC *Report No 944/1/04*). It is also important to determine the nutritional value and water requirements of these crops. The best combination between indigenous crops and a range of home-grown vegetables, and other foodstuffs to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (WRC *Report No 1267/1/04*). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosa, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of

a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households. Further consultation with stakeholders has to take place to develop the specific objectives and deliverables of this project.

Expected cost: R2 850 000
Estimated term: 2005-2010

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities
University of the Free State, Agricultural Economics
No 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on bio-physical aspects of in particular infield RWH&C has been done (see WRC *Report No 1176/1/03*). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC *Report No 1267/1/04*). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social- economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000
Expected term: 2006-2011

Productive use of domestic water for sustainable livelihoods
Nemai Consulting
No 1666

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional sources to improved water supplies and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor these additional requirements of water for poor communities to be able to sustain their livelihood. Further the general approach and thinking to productive uses is limited to small-scale agriculture; however in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities and establish the levels of supply that will be adequate. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000
Expected term: 2006-2008

NEW

THRUST 1: COOPERATIVE GOVERNANCE

Development of the AWARE model for the Inkomati CMA
Targeted Solicited
No 1573

This project was listed in the *2006/07 Knowledge Review*. The project title was: 'Processes and relationships between CMAs and other organs of society'. The topic has been covered by a number of other projects on cooperative governance and has been replaced with a more relevant area. The team that developed the AWARE model will be targeted to continue with populating and customising it for the Inkomati basin. The budget remains the same.

The new water management institutions have the complex task of matching different and sometimes-contradictory objectives in a socio-economic context characterised by inequalities, lack of or asymmetry of information, and conflicting interests. Hence, a clear need for negotiation and decision-support tools for these institutions is perceived. CMAs and WUAs will have to put in place processes of participatory decision making and facilitate negotiation among water users having different socio-economic characteristics, unequal access to information and knowledge, and therefore a different capacity with regard to lobbying and negotiation. The AWARE model is a tool developed for the KAT River as a simulation model involving role-playing games, able to represent the complexity and the uncertainty of the above-mentioned processes which has great potential to support the CMA board to make informed decisions.

Estimated cost: R1 800 000 (KSA1)
Expected term: 2007-2010

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity
CSIR Natural Resources & the Environment
No 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision-making in a situation of varying levels of certainty and of potential conflict. Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820 (KSA 2)
Expected term: 2007-2009

KNP river governance
The Shared Rivers Initiative Phase 1: Part A – Contextual profiles of the shared rivers of the Kruger National Park
No 1711

Research undertaken during this project will address a recently identified gap in the governance process of water resources in that a formal route of response to the red flag raised when a Threshold of Probable

Concern is exceeded during the Strategic Adaptive Management process needs to be defined.

There is growing concern among scientists, managers and the general public in South Africa about the continuing decline in the integrity of the river systems of South Africa's north-east Lowveld in spite of an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management.

The Lowveld river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland). Each has to achieve their own important resource management and water supply priorities within their portions of these basins. Each neighbour faces a similar set of needs and challenges in its attempts to balance social development imperatives with management for resource sustainability. There is a clear need to harmonise management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery.

This project aims to explore water policy implementation as a complex social-ecological and initiate an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management. During this process, an understanding will be developed towards managing the Lowveld rivers following a cooperative, international and basin wide approach.

Estimated cost: R1 500 000
Expected term: 2007-2009

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

The criteria necessary for the success of women in the water sector
Palmer Development Group
No 1762

A number of successful women can be found in the political, corporate and the business worlds in South Africa. Whether their success can be attributed to positive family endowments such as well-defined gender roles at the home and/or community levels, the enabling legislation in support of gender parity, etc., or a combination of all the above, might explain why still only few women manage to make it to the top echelons. The project will seek to personalise the success by investigating real-life examples to draw out the criteria necessary for the success of women in the water sector. The intention is to uplift those feeling disempowered and to identify gaps, if any, hindering the progress of women in the water arena.

Estimated cost: R712 320 (KSA 1)
Expected term: 2007-2009

THRUST 3: SUSTAINABLE USE OF WATER AS A SCARCE AND SHARED RESOURCE

Review of the involvements of national water institutions and civil society in international agreements in South Africa
Pegasys Strategic Management
No 1758

Water management institutional reform is taking place within most of the SADC countries, and new local catchment councils and/or agencies are already in existence in the respective countries. At higher interstate levels, Shared River Commissions are established in accordance with the SADC protocol on shared rivers. To date, little or no attention has been paid to the interaction and integration of local actors vs. international bodies and the quest to separate the governance and implementation/management dimensions in internationally shared rivers for effective management and long-term sustainable use of such resources. This project could look at some examples such as the Inko-Maputo Agreement and the roles and responsibilities of the different local and international role players to ensure effective implementation. Other examples can also be considered.

Estimated cost: R3 000 000 (KSA 1)
Expected term: 2007-2010

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa
Palmer Dev Group, Cape Town Office
No 1713

A study conducted in Johannesburg in 2005 indicated that consumer units are larger in poorer areas. This is due in part to the fact that consumer units frequently comprise more than one household - the study indicated that in the areas surveyed consumer units were made up of 2 to 3 households on average. Most of the research on larger consumer units in urban areas has focused on units that include backyard shacks. There has been little focus on the broader group of large consumer units, of which units with backyard shacks are just one component. The phenomenon of large consumer units poses a problem with regard to the affordability of water services. The research will investigate the phenomenon of large consumer units in poorer urban areas. The study will focus on the structure of large consumer units in poorer urban areas, and the extent to which these consumer units consist of multiple households (possibly living in backyard shacks, but also possibly sharing a dwelling). In particular, the study will examine how the members of large consumer units access water services, and how they pay for these services. It is anticipated that gathering this information will assist municipalities to refine their strategies around delivering free basic water services and inform the structure of water and sanitation tariffs, thus improving cost recovery for water services.

Estimated cost: R390 550 (KSA 3)
Expected term: 2007-2008

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities
Cape Peninsula University of Technology
No 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services.

Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of the operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324 (KSA 3)
Expected term: 2007-2009

Development of a framework and model to regulate the competencies and training of managers and technicians in the provision of water services
University of the Witwatersrand
No 1715

Currently there is a lack of an understanding of the appropriate generic approaches to qualifications, competence and skills in a technical sector such as Water Services. Reviewing the water services and related (municipal, health, construction, electricity) legislation and regulations, it is evident that there is a huge gap in identifying current institutional arrangements for regulating qualifications, competences, training and development. Furthermore, this is compounded by a lack of a conceptual framework and model for the qualifications competences and skills required for effective provision of water services. This study aims, on the basis of the engagement with stakeholders, to develop an appropriate framework for competences and skills in water services. It will develop an understanding of the specific qualifications, competences and skills that are required for the effective provision of water services in South Africa. Clarification of options and proposal of the mechanisms that can be used to ensure that necessary qualifications, competences and skills are available to all Water Services Authorities and providers.

Estimated cost: R350 000 (KSA 3)
Expected term: 2007-2008

Examine the understanding and interpretation of sanitation policy and programmes
Hlathi Development Services
No 1741

South Africa is faced with a sanitation backlog that has to be redressed by 2010, and at present policy and strategy focuses on delivery, rather than on sustainability of the sanitation services provided. The 2010 targets have been set by national government as being a basic level of sanitation because all effective sanitation must focus on people and not only the infrastructure. The primary focus of the policy is on the services provided by the water service authority, but also highlights that the end-user households share responsibility for good sanitation and effective sanitation practices. The water service authority is given the responsibility of monitoring and desludging of on-site facilities, and/or relocation of on-site toilets when pits fill. There are, however, no existing policies or strategies that set out the detail of how this process is to be implemented. This implies that the operation and maintenance of rural sanitation systems are less than optimum, leaving the user with a level of service that is below the national average. This has numerous implications for the user and national government. Amongst the implications are health and cost factors.

Estimated cost: R400 000 (KSA 3)
Expected term: 2007-2009

What do we do to accelerate sanitation?
Hlathi Development Services
No 1743

The need to accelerate the provision of safe and hygienic sanitation to the approximately 8 million South Africans who still lack it is an urgent priority. Safe sanitation and improved hygiene practices can save thousands of children's' lives every year. The dignity and quality of life of mainly poor people can be considerably enhanced. Government has accorded sanitation a very high priority and has committed itself to eliminating the backlog by 2010. However, at the current pace of delivery, this target will not be achieved. There is thus an urgent need to find ways to accelerate the pace of delivery, and to do so in such a way that the sustainability of the facilities provided and behaviour changes achieved are sustainable. The bottlenecks to faster delivery need to be identified and analysed, examples of how they have been successfully overcome documented, and tools and guidelines produced to help municipalities to achieve the required rate of sustainable service delivery. Ways also have to be found to reduce the cost of sanitation delivery to urban areas, and informal settlements in particular.

Estimated cost: R549 600 (KSA 3)
Expected term: 2007-2008

Free basic Sanitation – is it possible?
Hlathi Development Services
No 1742

The South African government has made a commitment to provide free basic water and sanitation services to the poor households. A review of progress in the implementation of the free basic water policy showed that the 3 poorest provinces are lagging behind with regard to the provision of free basic water (KZN, Limpopo and EC). More than 60% of the people without access to basic sanitation services are found in these 3 provinces. From this analysis, it is clear that the objective of providing free basic water and sanitation services to the poor households is proving to be difficult to achieve. The implementation of the free basic sanitation policy is more complex than water provision because of the different sanitation technologies that are used; e.g. for poor households with full water-borne sanitation, it is unclear whether the water for flushing or the cost of treating sewage should be subsidised. Should the municipalities be responsible for providing O&M for on-site sanitation? There is currently no policy for funding the relocation of superstructure for full toilets or construction of new ones where relocation is not feasible. Thus, there is a need to identify successful and cost effective approaches of implementing sanitation subsidies for sanitation infrastructure in order to achieve the 2010 sanitation target. Financial models and innovative strategies are required for assisting municipalities to provide sustainable free basic sanitation services to the poor household and to pay for ongoing O&M for these services. Good practice must be identified and scaled-up where possible.

Estimated cost: R700 000 (KSA 3)
Expected term: 2007-2009

THRUST 5: POVERTY ALLEVIATION

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa
ARC, Institute of Soil, Climate and Water
No 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorised as being ultra-poor. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas. Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned, but used communally by farmers for grazing domestic livestock and harvesting natural products such as fuel-wood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterised by abandoned croplands that are infested by weeds and grasses. In communal areas where individuals share land and water resources, understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is dependent upon the functioning of the institutional arrangements.

Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production, but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop-lands in communal areas will be produced.

Estimated cost: R3 200 000 (KSA 4)
Expected term: 2007-2013

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)
Umhlaba Consulting Group
No 1776

Water harvesting and conservation practices have been tested and demonstrated to be sustainable and contribute to food security. Many of these techniques and practices have been documented in the form of research reports and information material for public interest, but not packaged as training material for the end user. In addition, advisors and farmer support personnel such as extension services are often ill-informed and inadequately trained in agricultural water management, including water harvesting and conservation.

High illiteracy, particularly among the rural population, limits the ability of farmers to access information and to utilise new technologies. There is, therefore, a need for accredited yet appropriate training material for certified trainers and learners (farmers). Training, education and skills development will need to follow a broad-based approach that is aligned to government initiatives such as the Joint Initiative on Priority Skills Acquisition (JIPSA) and grounded on Outcomes Based Education (OBE) and Adult Basic Education and Training (ABET) principles. This project will develop a comprehensive learning package for the application of WH&C for household food production and poverty alleviation in rural areas. It will identify the existing unit standards for training in WH&C and fill the gaps in learning material by adopting and adapting available material and developing a comprehensive package (NQF level 4/5 facilitators guide for trainers, ABET levels 1 and 2 learning material for learners and assessment guide). The learning package will be tested in the field with trainers, facilitators and learners.

Estimated cost: R1 950 000 (KSA 4)
Expected term: 2007-2012

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WATER AND THE ECONOMY

Mr Meiring du Plessis | Head |

SCOPE

An investigation was launched during 2006 to review the Research Framework and Strategic Plan for future water-related economic research. Although a change in the Research Framework is being implemented, the scope of research addressed by this Impact Area will remain largely unchanged from previous years.

In the SA context water is, first and foremost, treated as a common (social) good. Water is recognised as being essential for sustaining life and is a commodity to which people and the aquatic environment have a legally protected right. However, water is also recognised as an economic good, the use of which has a major impact on the creation of wealth and the well-being of people. Almost without exception, there is an increasing interest in assessing the economic value of water, using water as a catalyst for the generation of wealth and prosperity, and using economic instruments to increase efficiency and effect desired behavioural change among water users. The use of water tariffs to effect changes in water consumption and the use of waste discharge charges to internalise pollution costs and, in so doing, effect pollution reduction and desirable improvements in water quality, are examples of management options that are being implemented along with the selling of water-use licences under specific circumstances. There is also recognition of the need to deal with complex water-economy systems such as catchments and to determine how sensitive socio-economic activities and their associated value are to the impacts of extreme events such as floods or droughts, or to gradual changes over the longer term, such as global climate change.

This Impact Area will continue to integrate the economic aspects of water-related investigations funded by the KSAs. It will also identify overarching issues that need to be addressed at a higher level of integration. Projects and activities under this Impact Area will determine the role of water in economic development, the use of economic instruments for improved water management and the economics of dealing with complex systems at the appropriate micro, regional and national levels.

OBJECTIVES

As in previous years, this Impact Area aims to be instrumental in integrating the economic aspects of water-related investigations that are under-way within the WRC's KSAs, and in identifying and initiating further important investigations that may be needed in this **Impact Area Water and the Economy**.

The primary aim of the research portfolio facilitated through this Impact Area is to demonstrate the applicability of economic principles in the water field and to provide convincing evidence as well as sound knowledge and support to water management institutions and implementing authorities. The legal framework is already reasonably accommodating and stakeholders are therefore expected to be receptive to the knowledge generated.

Secondary objectives are to:

- Assess the role of water in economic development
- Use economic instruments for improved management of water
- Deal with complex water economy systems.

THRUSTS

The thrusts which define the structure of this Impact Area's research portfolio have been changed following the completion of the new Strategic Investment Framework for Water-related Economic Research: 2007-2010, completed in early 2007. Previously the thrusts as presented in previous Knowledge Reviews were:

- The value of water to different sectors of the economy
- The economic advantages and disadvantages of water resource development
- The use of economic instruments to effect behavioural change regarding water utilisation
- The use of economic instruments to promote equitable and efficient water allocation and distribution.

The revised thrusts are presented below.

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

The ever-mounting scarcity of freshwater in South Africa within the context of an expanding economy and, thus, increasing demand will need informed choices on water allocation between competing needs. In general, there are 2 general choices to address this problem; either increase supply or reduce demand.

- With a renewed focus on public infrastructure development in South Africa the question needs to be answered what the best possible economic allocation of scarce resources to, or costs and benefits of alternative shorter and longer term water management options are, including enhancing supply and managing demand. Such analysis must also assist decision makers to determine and communicate the trade-offs resulting from water allocation decisions.
- A second and related question is whether South Africa's water resources are sufficient to support planned economic developments (such as those proposed in the Asgisa document), and what the sensitivity of such economic development plans are to changing assurances of supply, changing water prices and implementation of water conservation regulations and technologies. This would need an analysis whether water, as a specific resource, is a constraining factor in economic development in the first place.
- A third question is the role of water specifically in the alleviation of poverty. Although the WRC has a separate research programme on Water and Society, specific issues remain that are relevant to this Impact Area. One example is what the impacts of water redistribution are on economic growth as well as on broad-based black economic empowerment, two key objectives of government policy. Another example is an evaluation of the economic viability of emerging and small business in the water sector, such as small farmers and contractors.
- A fourth question in this key strategic focus area is to evaluate the economics of water service delivery, including water supply and sanitation, and to identify institutional bottlenecks hampering service delivery.

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

The next key element of the strategic framework is the question of how to apply economic instruments in the management of water.

- The first question is at what (volumetric) levels water prices should be set and how sensitive water demand is to changes in water prices, moving beyond single-point estimates on water valuation (elasticity). Prices and demand will have to be studied at various stages of the water supply chain and to different users, and need to test the affordability to water users throughout the chain.
- The second question is that non-market valuation techniques need to be applied to estimate the demand for those water-related ecosystems goods and services not traded in markets. Estimating the benefits of healthy water-related ecosystems and applying these to estimate the economics of the ecological Reserve are 2 topics in need of further research.
- A third question is what the benefits of clean water and the cost of addressing polluted water are. To achieve levels of water pollution that do not cause long-term damage, while leaving space for development; research on the damage costs and unit control costs for key pollutants and key polluting sectors is needed.
- The fourth question is focused on the prerequisites for efficient water allocation, specifically the accurate and cost-effective measurement of water use as well as the institutional economics of water rights and licences.
- The fifth question revolves around an economic evaluation of water policies and the application of economic policy instruments to water management. A regulatory impact assessment on the national Water Act is proposed, as well as practically focused research on the feasibility of water markets and (waste) water charges.
- Finally, the question of how the results of economic analysis can better be integrated in the policy-making process, needs specific research.

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

The causal relationships within complex water-economy systems need to be explicitly recognised and their sensitivity to biophysical and socio-economic change tested. Cause-effect relationships on larger-scale complex systems such as catchments are not necessarily obvious. Water needs to be managed for multiple uses in a sustainable manner. Integrated assessment and multidisciplinary modelling approaches are needed to provide a systems-wide perspective on the management of water resources. The sensitivity of socio-economic activities and the value associated with these activities need to be tested for the impacts of extreme events and gradual changes. Integrated water-economic modelling on a catchment level is needed to inform appropriate catchment management strategies.

Research portfolio

The funding for research projects supported by the various KSAs and focusing on this Impact Area, is estimated at about R6.9 million for 2007/08, which represents an increase of about 7% over the previous year. Of this, R4.5 million is for ongoing research and R2.4 million for approved new projects. The spending on new projects in this Impact Area has stabilised after a period of sustained increases from R200 000 in 2003/04, to R1.3 million during 2004/05, R2.4 million during 2005/06 and R3.0 million during 2006/07. The total estimated expenditure has increased from R3.8 in million 2004/05 to R4.5 million in 2005/06, R6.5 million in 2006/07 and R6.9 million for 2007/08. The planned expenditure on current and new initiatives for 2008/09 is estimated at R9 million. These strong increases point to a growing awareness within the different KSAs of the important role of economic considerations in the water sector.

RESEARCH PROJECTS FOR 2007/08

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape
Department of Agricultural Economics, University of the Free State
No 1250

Risk management in agriculture has become an important part of the management function for primary producers, industry and government. Irrigated areas account for about 30% of agricultural production, so growth in irrigated output per unit of land and water is essential. Improved efficiency in agricultural water use is required both to maintain productivity growth and to allow reallocation of water from agriculture to urban and industrial use. The primary objective of this project was to quantify the impact of market risk on the efficient use of irrigation water and to determine the multiplier effects of irrigation accompanied by a shift in production patterns, with reference to the middle and lower Orange River, on the regional economy of the Northern Cape Province (NCP).

The typical farm-model scenarios showed that a decrease of 20% in the price of table grapes reduced the return on capital investment from 37.4% in the base to around 18.5% (reduction of more than 50% in net farm income). This represents a huge decrease in profitability. It is also important to note that a 20% reduction in the price of table grapes is an average reduction. There is substantial variation between the prices that farmers actually receive, since it will depend on the markets where the farmers sell their fruit and on the cost structure of the exporter. In this regard, farmers can reduce their risk. The results also clearly indicated that a more diverse farming structure is a key strategy when it comes to reducing marketing risks. The results indicated that the optimum farm structure after a reduction in the price of table grapes is different to the observed farm structure. If farmers had better marketing information and the skills to interpret this information, they would have made different production decisions. The results for the two different macro-economic methodological approaches, i.e. the general equilibrium (CGE) model and the economic multiplies, are presented in the report. In the case of the CGE model a 20% decrease in the world fruit price was simulated. This shock was simulated to quantify its impact with specific reference to irrigation agriculture within the NCP. The results clearly show that the farm structure should have been more diversified. A more diversified farm structure enables farmers to absorb market failures more efficiently than with a specialised farm structure.

Cost: R1 333 729 (KSA 4)
Term: 2001-2008 (extended from 2005)

CURRENT

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

Water resource management for profitable small-scale farming along the banks of the Orange River
Department of Agricultural Economics, University of the Free State
No 1354

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment.

The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa.

Sub-aims are to:

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000 (KSA 4)
Expected term: 2002-2005

Development of an appropriate tool: Voice, measure and intervention in ensuring the sustainability of municipal water services to the poor
Human Sciences Research Council
No 1522

The main aim of this study is to determine or identify the water handling practices and behaviours which have a negative impact on users. Then use this as the basis to develop a framework for action and guidelines on improving hygiene behaviour. The study could break new ground and lead to new approaches which will lead to benefits in better health and hygiene promotion.

Estimated cost: R1 266 000 (KSA 3)
Expected term: 2004-2007

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development
Conningarth Economist
No 1570

With water being a limited resource it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2005-2008

Financial sustainability of sanitation services
Partners in Development
No 1632

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different

sanitation technology choices:

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall costing strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best practice case studies
- Exploration of credit finance options for household sanitation improvement programmes.

Estimated cost: R600 000 (KSA 3)
Expected term: 2005-2007

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities
University of the Free State, Agricultural Economics
No 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles. Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation is a broad-based strategy to improve rural livelihoods of resource poor and subsistence farmers. Substantial research work on bio-physical aspects of in particular infield RWH&C has been done (see WRC *Report No 1176/1/03*). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC *Report No 1267/1/04*). This last mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge. Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000 (KSA 4)
Expected term: 2006-2011

Effective demand for alternative sanitation options in per-urban settlements
Sigodi Marah Martin (Pty) Ltd
No 1664

This project offers an innovative approach of using tried and tested approaches of contingent evaluation approaches which aim to improve the science and understanding of sanitation demand by exploring and applying existing and tried and tested approaches to sanitation. Through this process it aims to provide knowledge and information as to what people in low-income areas are willing to pay for sanitation. This kind of knowledge and information is lacking. The lack of this information results in unpopular decisions and programmes being made on behalf of recipients. Further, this information could be relevant to informing policy at a national level and local level towards better programmes which are sustainable.

Estimated cost: R710 000 (KSA 3)
Expected term: 2006-2008

Productive use of domestic water for sustainable livelihoods
Nemai Consulting
No 1666

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional sources to improved water supplies. It is not well understood what the requirements in terms of quality and quantity of these water supplies are. Current approaches to providing piped water supplies to poor communities do not factor in these additional water requirements of poor communities to be enable them to sustain their livelihoods. Further the general approach and thinking with regard to productive uses is limited to small-scale agriculture. However, in many cases domestic water is used for many other productive uses. It is not also understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study seeks is that whether current levels of basic water supply are adequate to cover the productive use of communities and what levels of supply will be adequate. Secondly, it seeks also to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000 (KSA 3)
Expected term: 2006-2008

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa
Johannesburg University of Technology
No 1700

Over the years, the government has spent billions of rand to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation provision has brought to the communities and the countries. The WHO has over the years undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes, towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental). Thus, the time is most appropriate to undertake a study of this nature.

Estimated cost: R1 200 000 (KSA 3)
Expected term: 2006-2008

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

Valuing water for South African industries: A production function approach
Environmentek, CSIR
No 1366

The industrial sector in South Africa is one of the fastest growing sectors and relies to varying degrees (ranging from wet to essentially dry industries) on water resources as an input to many production processes. Industrial water use currently comprises about 10% of the total water use in South Africa (WSAM, 2000) and is therefore a significant water-

using (and effluent-generating) sector. Very little is, however, currently known about the responsiveness to water pricing within the industrial sector in South Africa, probably because of historically low pricing structures and the perception that industrial water use is better suited to engineering rather than economic analysis. International literature offers mixed results, with industrial price elasticities ranging from very inelastic to more elastic. In the context of the National Water Act and its emphasis on economic pricing, and the significance of industrial water use in South Africa, it is necessary to provide econometric tools to decisionmakers. The proposal aims to quantify and characterise the role that water plays in various local industries and their responsiveness to price changes; and to develop a set of indicators and judgement criteria for policy makers, decision-takers and other stakeholders to use economic analysis for appropriate water resource management.

The project's overall aim is to determine the marginal value of industrial water in South Africa, in keeping with the National Water Act's objectives to price water correctly. The specific sub-goals are listed below:

- To assess the role that industries play in the overall water demand for South Africa, and to determine which industries are the most water-intensive industries and which industries are relatively water 'dry'
- To determine price elasticities of demand for water for the respective industrial sectors within South Africa, and develop a set of indicators that can be used in existing models or assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge.

Estimated cost: R549 600 (KSA 3)
Expected term: 2002-2005

Valuation of estuary services in South Africa
Nelson Mandela Metropolitan University
No 1413

Estuaries are delicate systems that are not only in high demand for development, but also deliver important goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological process and functions, but does not adequately account for the values placed on estuaries by people.

This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 160 000 (KSA 2)
Expected term: 2004-2007

Development of a model to assess the costs associated with eutrophication
Umgeni Water
No 1568

Eutrophication and its accompanying effects is one off the intractable symptoms of water pollution associated with modern society. It diminishes the quality of our water resources for many uses and costly treatment is often required to overcome its negative effects. In the prevention vs. cure debate, it is important to not only know the cost of prevention, but also the cost associated with eutrophication when it occurs at various levels, in order to justify often expensive preventative measures. Knowledge of the cost associated with eutrophication will also help in determining and justifying the introduction of waste discharge charges. Similar to a study that assessed the cost to users that can be associated to water salinity, a multidisciplinary team will conduct this project to determine the cost associated to eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2005-2008

Towards the establishment of water market institutions for effective and efficient water allocation
CPH Water
No 1569

The National Water Act provides for the transfer of water use licences through a water market. A recent WRC review of the value of water to different sectors of the economy has revealed that the market mechanism has proved to be an efficient tool to effect the transfer of water to more efficient users and improve water use efficiency under South African conditions. However, due to high transaction cost, this mechanism is under-utilised. In order to utilise the efficiency of market mechanisms, it would thus be necessary to develop institutions that facilitate transfer and reduce transaction costs. On the other hand, safeguards also need to be instituted to prevent potential negative externalities associated with transfers. This project will focus on three case studies to determine which steps are required to balance these requirements.

Estimated cost: R1 500 000 (KSA 1)
Expected term: 2005-2007

Framework and manual for the valuation of goods & services of aquatic ecosystems for resource directed measures
Zeta Consulting CC
No 1644

The determination of the Ecological Reserve for a particular catchment area requires the integration of the catchment area's management class, the related Reserve and the resource quality objectives. In addition, benefit trade-offs with other water users also have to be considered. The NWRS recognises this by seeking to find a 'balance between protection and utilisation'. Therefore, in order to develop resource-directed measures (RDMs) that are technically sound, scientifically credible, practical and affordable, a framework and manual for the valuation of goods and services from aquatic ecosystems for the RDM are now required. The set of problems to be addressed here is therefore clear: in order to enable interpretation (and negotiation) of the likely consequences of changes in management class as embodied in the RDM procedures, the 'invaluable' aquatic ecosystem threshold must be determined, while trade-offs in ecological, social and economic benefits of the other management classes must be made transparent to users and other interested and affected parties.

This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R750 000 (KSA 2)
Expected term: 2007-2008

A pilot study into upstream cleaner production technologies for the petroleum refining industry to meet the requirements of the Waste Discharge Charge System (WDCS)
Process Optimisation and Resource Management
No 1673

The main objectives of the Waste Discharge Charge System (WDCS), imminently due for implementation by DWAF, are to reduce water pollution by encouraging efficient resource utilisation (incentive objective), recovering the costs of activities aimed at

pollution abatement and damage caused by pollution (financial objective), discouraging excessive pollution (deterrent objective) and promoting sustainable water use (social objective). This project aims to develop an understanding of the treatment processes, applicable to various industries, which could be used to meet the requirements of the WDCS. The project will use a petroleum refinery as a case study to investigate the financial impact of the waste discharge charge system on industry and to investigate source-reduction cleaner-production (upstream) options as opposed to an end-of-pipe treatment approach, exploiting a current real-life opportunity where these approaches to pollution prevention can be quantitatively compared. The specific aims of the project are to develop a prioritised list of upstream treatment technologies for the petroleum refining industry, and to quantify the financial implications to the petroleum refining industry of meeting the WDCS requirements.

Estimated cost: R229 200 (KSA 3)
Expected term: 2006-2008

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

Integrating flood-plain agriculture into a diverse rural economy by enhancing cooperative management: A case study of the Pongola
Institute for Natural Resources
No 1299

The effective management of the Pongola River flood plain has been unsatisfactory ever since the completion of the Pongolapoort Dam. This study aims at promoting effective cooperative management of the river system on a sustainable and democratic basis. Lessons learned here will contribute to formulation of policies and institutions to achieve sustainable use of river systems in rural South Africa. This project is strongly based on the principles of a participative action plan.
The aims of the project are to:

- Learn about promoting effective cooperative management around sustainable use of river systems in rural areas
- Redirect the pattern of resource use on the Pongola River flood plain towards a shared vision reflecting a diverse and sustainable economy
- Establish a confident and capable team of researchers drawn from previously marginalised sectors.

Estimated cost: R880 000
Expected term: 2002-2006

NEW

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa
Palmer Dev Group/Cape Town Office
No 1713

A study conducted in Johannesburg in 2005 indicated that consumer units are larger in poorer areas. This is due in part to the fact that consumer units frequently comprise more than one household – the study indicated that in the areas surveyed consumer units were made up of 2 to 3 households on average. Most of the research on larger consumer units in urban areas has focused on units that include backyard shacks. There has been little focus on the broader group of large consumer units, of which units with backyard shacks are just one component. The phenomenon of large consumer units poses a problem with regard to the affordability of water services. The research will investigate the phenomenon of large consumer units in poorer urban areas. The study will focus on the structure of large consumer units in poorer urban areas, and the extent to which these consumer units consist of multiple households (possibly living in backyard shacks, but also possibly sharing a dwelling). In particular, the study will examine how the members of large consumer units access water services, and how they pay for these services. It is anticipated that gathering this information will assist municipalities to refine their strategies around delivering free basic water services and inform the structure of water and sanitation tariffs, thus improving cost recovery for water services.

Estimated cost: R390 550 (KSA 3)
Expected term: 2007-2008

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities
Cape Peninsula University of Technology
No 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services.

Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of the operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324 (KSA 3)
Expected term: 2007-2009

Assessment of the contribution of water use to value chains in agriculture
University of the Free State, Agricultural Economics
No 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the agriculture sector plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and to improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-ranging program is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises how emerging producers can be included in the mainstream of the economy. Only by obtaining access to available resources or assets in agriculture, can an impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard, the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the

economy. It will investigate whether emerging farmers, who are producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development.

The main outputs will be firstly, a conceptual framework based on the literature review of value chain analysis with specific reference to water utilisation and competitiveness in agriculture. Secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticulture and field crop industries. Thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain; optimisation of water use in the whole value chain; mainstreaming of marginalised participants in the economy by integration in the value chain; employment creation and poverty reduction through the value chain; and improving competitiveness in the value chain.

Estimated cost: R2 430 000 (KSA 4)
Expected term: 2007-2012

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

Framework and manual for the valuation of goods and services from aquatic ecosystems for the Resource Directed Measures (RDM)
CIC International
No 1644

Knowledge concerning the socio-economic aspects of sustainable ecosystem management lags behind knowledge of the ecosystem functions and processes. Insight and application of aquatic ecosystem valuation needs to be improved.
This project will investigate and develop appropriate techniques which will determine the value of aquatic ecological functions.

Estimated cost: R750 000 (KSA 2)
Expected term: 2007-2008

Estuaries and economic empowerment
University of KwaZulu-Natal, Centre for Environment, Agriculture & Development
No 1705

Earlier phases of the East Cape Estuaries Management Programme researched the estuarine systems with the long-term aim of enabling communities living alongside the estuaries to generate income from the resource in a sustainable manner. Courseware was prepared and presented to local authorities (ranging from poorly to well resourced) on estuarine planning and management with a view to including the estuary in the Integrated Development Plan (IDP) of the Local Authority.

This follow-up project will focus on subsistence livelihoods and will examine such issues as economic empowerment, institutional arrangements, participatory governance in the light of opportunities available, and will establish a framework where identified opportunities can be picked up in the IDP process. Principles developed during this suite of projects will be applicable to wetlands and other areas where natural resource-based enterprises may be developed.

Estimated cost: R1 500 000 (KSA 2)
Expected term: 2007-2010

Free basic sanitation – is it possible?
Hlathi Development Services
No 1743

The South African government has made a commitment to provide free basic water and sanitation services to the poor households. A review of progress in the implementation of the free basic water policy showed that the three poorest provinces are lagging behind with regard to the provision of free basic water (KZN, Limpopo and EC). More than 60% of the people without access to basic sanitation services are found in these three provinces. From this analysis, it is clear that the objective of providing free basic water and sanitation services to the poor households is proving to be difficult to achieve. The implementation of the free basic sanitation policy is more complex than water provision because of the different sanitation technologies that are used, e. g. for poor households with full water-borne sanitation, it is unclear whether the water for flushing or the cost of treating sewage should be subsidised. Should the municipalities be responsible for providing O&M for on-site sanitation? There is currently no policy for funding re-location of superstructure for full toilets or construction of new ones where relocation is not feasible. Thus, there is a need to identify successful and cost-effective approaches of implementing sanitation subsidies for sanitation infrastructure in order to achieve the 2010 sanitation target. Financial models and innovative strategies are required for assisting municipalities to provide sustainable free basic sanitation services to the poor households and to pay for ongoing O&M for these services. Good practice must be identified and scaled-up where possible.

Estimated cost: R700 000 (KSA 3)
Expected term: 2007-2009

Implementation of ecological hazard assessment of industrial waste discharge at local municipal level, comparing toxicity test methods
Rhodes University
No 1757

The existing duality and debate on water as being both an economic and a social good, places a special consideration in the complex chain of supply of water resources especially to the poor in South Africa and the financial implications thereof. The daunting task for municipalities supplying affordable water, refrain from cutting connections and make the service sustainably available to all still remains a dream. If the ultimate goal of reducing poverty by 2015, it is very difficult to ignore the backward and forward linkages to making water available. New introductions of WRM charges and new CMAs will have cost implications. Overall, decentralisation is thought to make services more relevant and affordable, the project will test this hypothesis and make future recommendations on the appropriateness of pricing water in South Africa, especially for municipalities and agricultural sectors. The project will highlight areas for further research to assist in the implementation of financial arrangements; provisions, support, subsidies, etc. to poor water users.

Estimated cost: R200 000 (KSA 1)
Expected term: 2007-2008

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WATER AND THE ENVIRONMENT

Dr Renias Dube | Head |

SCOPE

The scope of research in the **Water and the Environment Impact Area** continues to improve the understanding of linkages between the natural environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) within the hydrological cycle as well as how these link with the anthropogenic environmental components (developed infrastructure and other land uses). The research in this Impact Area will also seek to establish and apply best practices in mitigation of damage to the water environment. This additional dimension of the research is expected to address environmental degradation through applied approaches which will rely on competent fundamental research.

This Impact Area promotes enhanced understanding of whole-ecosystem functioning in the context of the broader environment and its effects on water resources, and supports the development and application of good environmental governance systems. Activities within this Impact Area contribute to sustainable water resources management that meets the changing needs of society, by combining:

- Our understanding of good governance principles with
- Our knowledge of environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) and processes within the hydrological cycle.

The primary focus of the Impact Area will continue to be integrated into existing and new insights generated by research within and between the KSAs and by other institutions working in related fields. Although this Impact Area is characterised by integrating research at a high/meta-data analysis level, it is recognised that such research is only possible on the assumption that we have a sound foundation of appropriate basic research (and data) in place.

OBJECTIVES

The objective of the Impact Area is to contribute to achieving a situation where our governance systems and our understanding of environmental processes and functioning within the hydrological cycle are aligned to support sustainable water management that meets the needs of society.

THRUSTS

The thrusts are the same as those which have been applied in the past 2 years with an additional scope to improve understanding in mitigating environmental degradation and reverse the damage caused to the natural and the developed environment by water through anthropogenic activities.

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

All environmental components and processes within the hydrological cycle depend on and are regulated by the structural, functional and compositional aspects of biodiversity. Environmental components and processes also respond to and impact on society's decisions and actions. Historically, research has been narrowly focused on separate environmental components within the hydrological cycle rather than the processes and relationships between them. This thrust focuses on understanding these relationships within the hydrological cycle, their role in maintaining flows of water-related goods and services to society, and their vulnerability to change in the broader environment.

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Internationally, good governance is based on principles such as inclusivity, representivity, accountability, efficiency and effectiveness, as well as social equity and justice. In turn, good environmental governance should reflect our best understanding of the structure, functions, processes and variability that typify natural systems. Although there has been considerable development within the field of public, corporate and natural resource governance, little attention has been paid to the development of good environmental governance systems.

This thrust focuses on water-related governance within society and the design of systems that better anticipate, reflect and respond to changes in environmental components and processes within the hydrological cycle.

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

This thrust focuses on the generation, application and communication of higher-level knowledge and understanding of ecosystem approaches to water resource management and water use. The higher-level knowledge targeted should recognise and account for natural processes and human-induced impacts that affect water resources. This is achieved through research and workshops which stimulate the generation of new insights and information, through:

- Synthesising outputs from relevant programmes and projects within the WRC's research portfolio
- Combining these with the findings of other relevant national and international research initiatives and
- Influencing and initiating appropriate new research and other initiatives to address environmental issues that cut across various water-related subject areas.

THRUST 4: ENVIRONMENTAL DEGRADATION AND MITIGATION

This thrust will seek to maintain and enhance the benefits of water to the environment, mitigate environmental degradation and reverse the damage caused to the natural and the developed

environment by water through anthropogenic activities. Water in its different characteristics which can be detrimental to the environment will go through retrospective and prospective research to develop practical solutions for addressing environmental degradation. These practical solutions for mitigating and addressing environmental degradation will be applied in a way that enhances social, economic and ecological benefits. This thrust will tend to align the research in this Impact Area to more evident solutions that are expected to touch the lives of those people who are exposed to degraded environments. The thrust will package, expose and enhance the applied research dimension to the mostly fundamental research in the different KSAs. The research in this area will also target the promotion of clean water environments through community-based research.

Research portfolio

The funding for research projects relevant to this Impact Area and supported by the various KSAs is estimated at R35.6 million for 2007/08. The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

RESEARCH PROJECTS FOR 2007/08

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

The assessment of short-, medium- and long-term impacts on groundwater quality associated with the filling of dolomite cavities
Metago Environmental Engineering
No 1122

De watering of the dolomitic aquifers overlying ore bearing reefs has, since the 1960s, resulted in the formation of a large numbers of cavities in the dolomitic compartments on the West Rand. Some cavities have been filled with various mine waste materials including gold mine tailings and waste rock. The State Technical Committee for Sinkholes had raised the alarm about the potential for groundwater contamination as a result of this practice. These cavities have to be filled for safety reasons and to prevent inflow of surface water which would aggravate ground instability, accelerate recharge of the mine void and hence increased pumping costs. Slimes material is the most economical material for filling cavities. This investigation focused on the impact that the future filling of cavities may have on groundwater quality and the effectiveness of alternative fill materials and methods.

On cessation of mining, the water in the dolomite compartment is expected to rise to the same level as was present prior to mining. The time to reach the final level is provisionally estimated to be between 11 and 30 years after mining ceases.

A geochemical model was developed to predict the quality of leachate and its impact on the groundwater in the immediate vicinity (directly below) the backfilled sinkhole over time. With the exception of uranium, the leachate quality from the gold tailings backfill does not pose a significant health risk to humans that use the aquifer in future. Heavy metal poisoning due to groundwater consumption is mitigated by the high pH buffering capacity of the dolomite water which ensures that any dissolved metals entering the aquifer, if not diluted, will be readily precipitated, keeping heavy metal concentrations at safe levels. Uranium could exist in the aqueous form under both acidic and alkaline conditions, only the speciation varied.

A separate model was developed to evaluate the combined effect of a number of similar backfilled sinkholes on the entire compartment. The model showed that the backfilling of single isolated sinkholes with gold tailings cannot adversely affect dolomite water quality with respect to uranium, irrespective of the uranium leachate concentration. However, the backfilling of clusters of sinkholes (comprising of 30 or more in a 1 km² area) could result in the development of a uranium pollution plume over time. The more extensive the cluster, and the more concentrated the sinkholes in geographic extent, the greater the risk of pollution. Uranium leachability is the single most important factor in deciding the sustainability and hence acceptability of using gold tailings to backfill sinkholes. Provided that the uranium leachability is below 0.8 mg/l, the risk of pollution levels increasing above background by more than the SAWQ guideline level of 0.07mg/l is insignificant. The WHO guideline value of 0.002mg/l U has a higher risk of being exceeded.

The physical stability of backfilled sinkholes was determined to evaluate the sustainability of the current backfill practices and identify those factors that should be considered in the design and method of backfilling to reduce the risk of re-activation of backfilled sinkholes. Backfilling of sinkholes with purely non-cohesive materials poses a significant safety risk to humans due to the risk of sudden subsidence, caused by reactivation of the sinkhole. Backfilling of sinkholes with a cohesive material such as clay or cement-modified gold tailings material may significantly reduce the risk of occurrence of subsidence or re-activation. Backfilling with natural material from borrow areas in close proximity to sinkholes has the disadvantage of depleting the surrounding area of soil and also increasing the risk of sinkhole formation in the borrow area as a direct result of changed drainage conditions.

A legal review showed that the practice of backfilling sinkholes with tailings or mine waste rock is not in compliance with the law. The issue is however complex as a result of historic agreements between the Government and the mining industry and past decisions and precedents. Sinkholes will have to be secured for the safety of the public and structures in the close proximity to sinkholes. Furthermore since open sinkholes are associated with a significant risk of illegal dumping, backfilling of sinkholes appears a logical and appropriate solution. Further consideration to resolve the legality of the backfilling practice will, however, be required should mine waste materials be used in future for this purpose.

Cost: R440 000 (KSA1)
Term: 2000-2002

Field investigations to study the fate and transport of DNAPLs in groundwater
Institute for Groundwater Studies, University of the Free State
No 1501

Dense non-aqueous phase liquids (DNAPL) contamination is a worldwide phenomenon which has been thrust upon developing countries during recent years. The results of this project are the state-of-the-art for DNAPL related studies in Southern Africa. The project objectives were to:

- Identify flagship field sites where DNAPL site characterisation methods and natural attenuation processes will be evaluated and tested during the project
- Evaluate rapid methods for the delineation of DNAPL contaminated zones
- Conduct field and laboratory scale based studies in order to identify and predict critical factors for DNAPL flow and transport under South African aquifer conditions
- Assess the viability of natural and enhanced attenuation processes of DNAPL contaminated zones
- Establish methodologies for DNAPL site characterisation and Monitored Natural Attenuation (MNA)
- Develop guidelines for the construction of conceptual models of DNAPL contaminated sites
- Develop appropriate guidelines for monitoring systems of DNAPL contaminated sites.

Research on this topic was done on 2 separate test sites and supported by a diversity of laboratory experiments.

Four different products have been delivered:

- *Manual for Site Assessment at DNAPL Contaminated Sites in South Africa*
- Groundwater monitoring guidelines for DNAPLs in South African aquifers
- Guidelines for the acceptance of monitored natural attenuation processes in South Africa
- Handbook for DNAPL contaminated sites in South Africa
- Results of field investigations to study the fate and transport of DNAPLs in groundwater.

Cost: R3 058 000 (KSA1)
Term: 2004-2007

Mine-water irrigation return flow
Institute for Groundwater Studies, University of the Free State
No 1507

Research over a period of more than 10 years that concluded with **WRC Project No 1149**, has provided proof about the shorter term feasibility and sustainability, from an irrigation perspective, of using gypsiferous waters for irrigation of a range of crops. Minimal contamination of groundwater was observed over this period. However, the larger scale implementation of this practice is hampered by concerns of regulators regarding the long-term impact that large scale mine water irrigation may have on groundwater quality and quantity. This project undertook research at five sites where gypsiferous water was used for irrigation to determine the hydraulic interaction between irrigated mine water and underlying aquifers, its effect on the hydrology and water quality at opencast spoils and undisturbed areas, salt migration and attenuation, and to establish criteria for site selection and operation.

Soil profiles under irrigation were found to have a high water content, which increases above clay rich layers. Approximately 80% of the salts applied over the years of irrigation were contained in the top 2 m of the profile, with the top metre being gypsum saturated; 40-50% of salts were dissolved in the soil water, while the balance was either precipitated or sorbed by the soil. Geochemical modelling provided similar results. This implies that over the short to medium term, irrigation did not influence the aquifers to a great degree. Dissolved salts leach to the aquifers at very low rates and are diluted at such a fast rate by the regional lateral groundwater flow, that only low concentrations are detected through borehole sampling. In the short to medium term, the evidence thus shows that irrigation with gypsiferous mine water does not hold significant threats to the regional groundwater quality.

One of the most promising applications of irrigation with gypsiferous water is its application to rehabilitated opencast spoils. These areas have already been impacted by mining and the salts leached from irrigation can be regarded as being fed into the same system from which they originate. Laboratory and field studies, together with geochemical models, were carried out to determine the behaviour of the spoils under various irrigation conditions. The cumulative understanding developed from these studies, allowed the construction of feasible conceptual reaction models to predict the outcomes from alternative scenarios. The reactive nature of the spoils is very important in this regard. The potential for acid generation is a very important indicator, while it is also clear that in high sulphide areas, the irrigation will enhance reactions and therefore lead to more rapid acidification and a higher salt load generation. Where recirculation is practised, it is important to use gypsiferous water, as waters with highly soluble constituents will not precipitate and concentrations will continue to rise to very high levels.

The project has developed a set of criteria for site selection/operation, monitoring, determination of impacts, and mitigation methods for irrigation with mine water, which have been combined into a user-friendly software application entitled 'Groundwater Impacts of Minewater Irrigation' (GIMI). GIMI takes the site-specific conditions of crop types, climate, water quality, soil properties, irrigation water quality, size of irrigation area, spoils geochemistry, aquifer properties and closest receptors into account to recommend whether the irrigation is viable and what monitoring needs to be put in place. All of this should allow mine water irrigation to be considered, managed, regulated and implemented as part of responsible mine water management, with a far higher degree of confidence than was previously possible.

Cost: R445 650 (KSA1)
Term: 2004-2007

Development, testing and installation of a real-time ecological Reserve implementation method for the Thukela River
Rhodes University, IWR
No 1582

This project aimed to develop and test a real-time Reserve implementation method based on the Thukela River, and to install the system in the KZN DWAF Regional Office. Previous experience on reserve implementation had identified the need for suitable hydrological triggers to be used to specify the Reserve flows required in real time. It also identified some of the limitations of the Regional Offices of DWAF to deal with, and make use of, the Reserve information supplied by the DWAF RDM Office. Some concepts of how the triggers could be provided and how the implementation methods could be packaged emerged from the Thukela Reserve determination and were further explored by a previous WRC project (K8/510). Both of these projects concluded that the best method for low flow management is likely to be based on the near real-time collection of rainfall data and the application of the Pitman monthly rainfall-runoff model. Further work is still required to address the issues of triggering high flow releases from reservoirs to meet the high flow requirements of the Reserve. One of the critical aspects of developing an implementation system is that it must be able to be used in practice and a major component of this proposed project is to package the range of estimation and modelling tools in such a way that it will be able to be used by Regional DWAF water resource managers and later CMAs in the future. The developed tool will be generic and therefore applicable to other rivers where Reserve requirements need to be managed in real time.

Cost: R 690 800 (KSA 2)
Term: 2005-2007

The determination of annual phosphorus loading limits and land-use-based phosphorus loading models for 30 key South African dams in relation to their present and likely future trophic status
W Harding (Private Consultant)
No 1687

The point of departure in eutrophication assessments is to determine the relationship between the level of nutrient loading, in particular phosphorus, and the in-lake condition. A number of simple relationships exist for predicting in-lake phosphorus conditions based on hydro-morphological data and catchment land use. This project aimed to assess the relevance of such screening-level assessments across a wide range of South African impoundment types by testing a suite of models across a set of 30 dams.

Although unforeseen data limitations reduced the modelling set by 17, the aims were achieved for the remaining 13. The approach proved to be workable notwithstanding the identified need for a greater level of primary data sourcing and processing. As such the approach provides a means whereby impoundments and their catchments can be screened for their trophic status, sources of nutrient loading in relation to land use, and Best Management Practices allocated accordingly.

This project has used flushing-corrected, annual time-step phosphorus models to analyse the conditions in a set of South African dams. Nutrient loadings to each dam were determined using a trial set of phosphorus export coefficients allocated to land-use practices. Model relevance (accuracy) was determined by comparing predicted vs observed in-lake phosphorus concentrations. Models calibrated

in this fashion allow for a desired total phosphorus load to be determined by reducing the loading to the point where the model output approximates the assumed 55 µg -1 TP phosphorus boundary concentration. While this approach has proved to be workable it remains subject to data constraints and verification of the relevance of the export coefficients used. Notwithstanding this the approach was used to determine Target Median Annual Phosphorus Loads (TMAPLs) for the dams in the test set.

No one model was found to apply to all of the dams that could be modelled. However, the Walker Reservoir Model, previously used for the Nutrient Enrichment Assessment Protocol (NEAP), again appeared to have strong relevance for South African conditions, i.e. for impoundments with relatively short (< 2-3 years) water retention times. As with the findings of previous studies the Combined OECD model was found to be generally applicable. The data constraints experienced in this project preclude reaching a definitive conclusion on model relevance and the re-calibration of any particular relationship for South African use.

All of the dams in the test set were in the eutrophic to hypertrophic range, with median annual in-lake phosphorus concentrations ranging from 31 to 626 µg TP -1. Targeted load reductions were found to be high, ranging from 25 to 96% of current loadings. Eight of the thirteen dams evidenced load reduction requirements in excess of 50%, and five of these greater than 75%. These data indicate the severity of the eutrophication problems being experienced by these waters. The dams in the test set could be divided into three types, those dominated by urban sources of nutrient loading, those dominated by dryland and/or undeveloped land use, and a mix of the two. In the cases of urban landuse dominance the primary source of nutrient enrichment is assumed to be treated wastewater effluents high in phosphorus content. Such sources are further deemed to be more suited to rapid nutrient attenuation (process upgrades), although not without significant cost implications, than are the more diffuse sources associated with dryland and non-irrigated agricultural practices within the catchment.

Cost: R243 750 (KSA1)
Term: 2006-2007

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Industry-government partnerships for the development of sector-based standards for the water environment
Karin Bowler Enterprises
No 1511

Negotiated Environmental Agreements (NEAs) offer alternatives in an effort to achieve environmental compliance. This legal mechanism which has recently been introduced into South Africa combines elements of regulation, self-regulation and co-operative relationships. The primary aim was to improve dialogue between diverse stakeholders and also with government to encourage change in traditionally reactive paradigms towards environmentally-focused regulation. Internationally, all NEAs focus on setting objectives above the legal requirements; in South Africa, this principle is contained in section 35 of the National Management Act (107 of 1998) in the form of Environmental Management Cooperation Agreements (EMCAs).

The intention of this research project was to determine whether Section 35 EMCAs or other forms of NEAs would serve as effective mechanisms to achieve environmental compliance in the water sector.

The process to establish an NEA for the South Africa Metal Finishing Industry in KwaZulu-Natal (MFI) formed the basis for this research. The National Water Act (36 of 1998) (NWA) and the Local Government: Municipal Systems Act (32 of 2000) (MSA) are the two laws relevant to this industry. Three interrelated components crystallised from the research process as the key findings and recommendations underlying the current status quo of NEAs.

The establishment of a Municipal Court should be a priority. Environmental justice can be promoted by educating Magistrates on the financial and environmental implications of non-compliance. This system will relieve pressure on the Department of Justice by expediting municipality-related cases; numerous are water-sector related.
It is recommended that a 'feebate' be introduced. Companies can benefit from compliance (a financial rebate is offered.) The substantial penalty is issued for non-compliance (a 'fee' or a tax). The Municipal Court system will also present an opportunity to increase fines issued by the municipality.

The MFI perceives NEAs as a means for government to avoid being held responsible for effective enforcement. The MFI is concerned that self-regulation may be a mechanism by which unfair competition practices within the industry are implemented.

An NEA is a strong tool for co-operative relationships if properly structured. The MFI is encouraged to strengthen the industry's Code of Conduct to improve business and operational standards. Comments from the MFI indicate that an improvement in government capacity may contribute towards improving attitudes.

Existing water-related regulations are robust and should achieve environmental compliance. As such the legal form of an NEA, i.e. NEMA Section 35 EMCAs specifically could be considered superfluous in the water sector. NEAs can potentially complement existing regulations and provide a mechanism for constructive dialogue within the water sector; this could in time mature into a platform to encourage the concept of co-regulation. However, lack of government capacity is undermining the existing regulatory framework and the potential for future NEAs. This has resulted in negative attitudes permeating government and the MFI. If extrapolated to other sectors the longer term implications do not augur well for economic sustainability for local government and industry.

Cost: R400 000 (KSA 1)
Term: 2004-2006

Implications of South Africa's trade policies for water policy and water resource management
University of Pretoria
No 1564

Following South Africa's transformation to democracy, the country has seen major shifts in virtually all policy fields, including water management and international trade, which are of relevance to this project. Much of South Africa is considered 'water stressed' (DWAF, 2004) and competition over water resources between water use sectors is likely to increase. At the same time South Africa has been re-integrated into the international trade system, in which it fully participates as a member of the World Trade Organisation (WTO). South Africa has to align its policy objectives with respect to water resources management and water services with its obligations from international trade law in a way that is most beneficial to the country and its people. The objectives of the project were therefore to:

- Identify options to harmonise policies and laws in the two fields of water management and trade, and to ensure the protection of domestic policy objectives in the light of obligations resulting from international trade agreements
- Recommend channels for improved communications between government departments to ensure optimal policy harmonisation.

As one of the outputs, the Strategic Review of the Implications of South Africa's Trade Policies for Water Policy and Water Resources Management provides an overview of the various linkages between water and trade issues. This represents a first step towards developing an understanding of the inter-connections between trade and both water resources management and water services provision. The strategic review also highlights that there is a need for greater cooperation between government departments on water/trade issues and particularly when it comes to trade negotiation strategy development.

The latter issue was addressed in a report highlighting possible channels for improved cooperation between government departments on water/trade issues. During this project it was proposed by the DTI that cooperation structures be established with DWAF in order to discuss water-related issues and take them into account in the Regional Industrial Development Strategy (RIDS) planning process currently underway. This suggestion was also supported by some of the DWAF representatives consulted. These cooperative structures could take the form of a permanent arrangement – or may be an ad hoc committee formed between the two departments specifically to provide input and exchange information on the RIDS.

Based on the linkages identified in the strategic review, the report includes a discussion paper that explores some of the most pertinent issues with the specific objective of highlighting possible misalignments between current South African water policy and obligations resulting from international trade agreements. The report points out where South African policy is, or could be in the future, at odds with international trade law provisions and proposes possible mitigation strategies.

Cost: R530 000 (KSA 1)
Term: 2005-2007

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater
Council for Geoscience
No 1431

The overall objectives of the project are to provide a basis for the South African authorities to safeguard groundwater consumers from exposure to toxic trace elements, and to determine whether or not leach testing on representative bedrock, or reliable geochemical models can be used to predict natural groundwater contamination in different regions. The trace elements of interest in this project are arsenic, chromium and uranium. The field investigation sought to sample a broad range of geological settings across South Africa and covered the following regions:

- Giyani and Gravelotte greenstone belts
- Eastern Bushveld
- Rooiberg tin fields
- Karoo coal fields
- Bushmanland
- Beaufort West and Sutherland.

The field investigation made the following main findings:

Arsenic was measured in harmful levels in one Giyani and three Beaufort West boreholes. Only one farm borehole was among this group (in Beaufort West) and the rest were mine or exploration boreholes. There was potential for speciation of arsenic in the more toxic arsenite form (As III) at approximately 10% of boreholes, including the Giyani borehole above.
Chromium was not measured in harmful levels in any boreholes, although was present in low concentrations at most. There was potential for speciation in the more toxic hexavalent form (Cr VI) at only one Karoo coal fields borehole.
Uranium was measured in harmful levels in 13 boreholes in Bushmanland and Beaufort West, and at low levels in some others. The boreholes in the former region were mostly located on farms, whilst those in the latter included one farm borehole and two exploration boreholes. According to water quality guidelines, the uranium levels measured on the farms should not pose a threat to most healthy individuals.

In general the various leach tests on non-ore-body samples yielded relatively minor quantities of the contaminants of concern for the current study (As, Cr and U). Some higher levels of these metals were leached from some samples collected in mineralised zones; however water in these areas would not normally be used for drinking purposes. Batch leach test results showed very weak, insignificant correlations with groundwater collected at corresponding sites, for all three elements of concern.

The leaching results support those of the geochemical modelling, in that the naturally elevated levels of hazardous trace elements in groundwater observed in field sampling are unlikely to be the result of simple interactions between groundwater and the surrounding aquifer material. More likely, it is the result of interactions within local mineralised zones within aquifers or recharge areas, or localised anomalous geochemical zones within aquifers.

Cost: R900 000 (KSA1)
Term: 2003-2007

CURRENT

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

Development of a system of simplified methods of vegetation water use based on the principle of limits to evapotranspiration
Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch
No 1319

Water resource managers will increasingly need to assess whether proposed changes in land use within catchments are likely to significantly reduce the quantity and temporal availability of water to downstream users. Such decisions need to be based on the relative annual (and perhaps seasonal) water use of the existing and proposed new crops or vegetation. The National Water Act makes provision for declaring certain land-covers (crops) as SFRAs (e.g. commercial afforestation) but it is likely that other land-cover changes may also have a significant impact in some situations. The principle of limits to evapotranspiration will allow for the limiting factors to be identified in particular situations and thus for a screening of land-cover changes based on the likely impacts. It could also provide a useful framework for interpreting the impacts of regional climate change in South African situations.

The aim of this project is to develop a framework of understanding about the major controls of evapotranspiration in different types of vegetation and crops in South Africa. This work will lead to:

- A better understanding of when a change in land-cover may have a significant impact on surface water yields from a land parcel
- Recommendations for simple models to use in assessing these impacts, easing the task of simulating water use in the wide variety of vegetation, indigenous and alien, existing in South Africa.

Estimated cost: R1 013 000 (KSA 4)
Expected term: 2002-2005

Ecological and environmental impacts of large-scale groundwater development in TMG aquifer systems
CSIR / Umvoto
No 1327

There is currently a debate concerning the extent to which groundwater abstraction from TMG aquifers will lead to environmental impacts. This debate will continue and inhibit better understanding of the water resources as well as inhibit development of the groundwater resources. Appropriate investigations are required to adequately inform key players and interested and affected parties, and to move the debate constructively forward.

This project aims to assess the dependency of aquatic and terrestrial TMG ecosystems on groundwater and predict impacts of groundwater abstraction. These ecosystems include wetlands, highland seeps, the riparian zone and spring discharge sites, amongst others. Specific objectives are:

- The development of predictive tools to assess the impact (or risk) of groundwater abstraction on the environment
- To improve our understanding of groundwater-dependent ecosystems (GDEs) in the TMG and the sensitivity to groundwater level fluctuations
- The use of innovative techniques to determine the impact of groundwater abstraction on the environment
- The development of indicators to monitor the effect of abstraction on sensitive ecosystems
- Coupling time series and spatial databases in order to ascertain the impacts of low flows (groundwater and surface water interaction) on the environmental system
- Improved understanding of the impact of changing low flows on freshwater ecology
- Improved understanding of the relationship between surface flow, event discharge from high-lying TMG unconfined aquifers and deep confined-aquifer discharge in maintaining wetlands or seeps
- Improved understanding of subsurface TMG discharge in maintaining coastal plain wetlands and vleis.

Estimated cost: R2 201 327 (KSA 1)
Expected term: 2002-2005

An investigation into the impact of landfill leachate on the physical, chemical and microbiological quality of the Soutpan Stream and its immediate surroundings
Department of Chemistry, Technikon Northern Gauteng
No 1341

The Soutpan Stream runs past a very poorly managed landfill site which serves the local Soshanguve community. The landfill is used for dumping of domestic and industrial wastes. Visible leachate is observed on a regular basis running into the Soutpan Stream. The Soutpan Stream serves a huge informal settlement as sole water source and thus presents a health hazard. The community uses the water for household practices, gardening and for animals to drink.

This project aims to improve the situation and make the water and the landfill practices acceptable according to set guidelines. This will serve as an upliftment project for the community as we will make use of their experience and knowledge.

The research aims to:

- Conduct an environmental inventory and audit of the study area
- Obtain information on how the landfill site is managed, the hydrogeological conditions, attenuating factors, weather patterns, volume and type of waste dumped, the volume and characteristics of leachate produced
- Investigate the direct and indirect physical, chemical and microbiological impacts and consequences over a defined range of temporal and spatial scales of the leachate generated at the poorly managed landfill site on the Soutpan Stream and its immediate surroundings
- Suggest measures which will help to minimise any adverse impacts on the environment and human health.

Estimated cost: R386 000 (KSA 3)
Expected term: 2002-2004

Facilitating the free passage of migratory aquatic biota in South African rivers
Consortium, University of Stellenbosch (lead agent)
No 1409

The need to manage water has led to the construction of barriers in rivers, effectively fragmenting the habitat and curtailing the passage of migratory biota. This project will develop protocols for assessing the extent of blockage to free passage, and so prioritising river systems for remedial measures, for the assessment of sites for use in the EIA and the RDM process. Understanding of the biological/hydraulic requirements of relevant biota will be developed and this, together with data from existing fish-ways, will be used to develop cost-effective designs for local biota.

Estimated cost: R2 000 100 (KSA 2)
Expected term: 2003-2007

Environmental water requirements in non-perennial systems
University of the Free State
No 1414

Methods for the determination of environmental flows for the reserve have been developed and used for rivers with permanent flow. However, many rivers in the semi-arid west of the country are ephemeral. The NWA requires that the reserve be determined before licences may be issued, and currently used methods have not been verified for ephemeral rivers. Verification needs to be done and, where necessary, new methods developed.

Estimated cost: R2 000 000 (KSA 2)
Expected term: 2004-2007

Habitat use and movement of freshwater fish
Freshwater Research Unit, University of Cape Town
No 1483

This project presents a unique opportunity to investigate the movements of large fish in an un-impounded river, the Doring River in the Western Cape. This is knowledge which can not be obtained from elsewhere in the country as there are so few un-impounded rivers remaining. The two things making this opportunity unique are that the Doring River, which is one of the last un-impounded rivers in the country, will be impounded within the next decade or so, and that we have a researcher capable of the task.

DWAF have asked for information on the movements of fish in a river system for use in their planning of fish-ways, and this research will complement the existing projects researching fish-ways by providing additional information that these projects will not be able to provide.

This work has previously been funded as a consultancy, and progress has been made both in the initial aims of the project, as well as in the sourcing of funds for the radio telemetry tracking of the fish.

Estimated cost: R688 000 (KSA 2)
Expected term: 2004-2007

Integrated management of water hyacinth in SA
University of the Witwatersrand
No 1487

Water hyacinth is difficult to control and is a problem world-wide. Chemical control is expensive and ineffective in the long term. Biological control has provided a sustainable and cost-effective control in certain conditions, but the harsh South African winters are more detrimental to the control agents than the weed, allowing the weed to regenerate in spring of each year. This project will refine earlier work (**WRC Project No. K5/915**) to control this problem weed by low-dose levels of certain herbicides without unduly damaging the populations of the control agents.

Estimated cost: R1 655 600 (KSA 2)
Expected term: 2004-2007

Land-use impacts on salinity in Western Cape waters
University of Stellenbosch
No 1503

Dry-land salinity is widespread throughout semi-arid regions of the world and its occurrence in some of the major catchments of the Western Cape is therefore not surprising. Wheat lands in the

Swartland and Overberg regions are widely known to contain 'brak kolle' (saline scalds) where the wheat will not germinate. Such saline soils are already recognised as a source of some of the salts affecting the quality of water in major Cape waterways such as the Berg River, where tributaries draining Malmesbury shale-derived soils are known to contribute disproportionately to the salt load. What does not seem to have been addressed yet in the numerous studies of salinisation of major South African rivers is the possibility that changes in land use from extensive pastoral use to intensive cropping over the last century or more may have triggered the same process of salt decantation as that which is so widespread in Australia. This is particularly likely in the semi-arid wheat lands of the Western Cape, which receive most of their rain during the winter months. The key question: is the dry-land salinity in catchments such as that of the Berg River more intense now than it was several decades ago and is it still intensifying? There is already substantial evidence of soil and groundwater salinity in the catchment but more systematic quantification is still needed.

Estimated cost: R1 995 880 (KSA 1)
Expected term: 2004-2009

Persistent organic pollutants (POPS) in the water environment
University of the North West
No 1561

South Africa is a signatory to the recent Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on POPs in the water environment, this research now needs to be taken further in order to:

- Better identify and quantify the fate and effect of selected POPs in the hydrological cycle
- Assess with higher confidence the scale and significance of the occurrence of POPs in the environment in South Africa, and the potential short-term and long-term impacts on water resources and water-linked ecosystems
- Support the development of appropriate policy and regulatory measures to ensure implementation of the requirements of the Stockholm Convention.

Estimated cost: R1 500 000 (KSA1)
Expected term: 2005-2008

Secondary and tertiary impacts on water resources due to primary changes in temperature and precipitation
University of Cape Town
No 1562

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality, water quality and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function, with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R2 500 000 (KSA1)
Expected term: 2005-2008

Flow conceptualisation, recharge and storativity determination in Karoo aquifers, with special emphasis on the Eastern Cape (Mzimvubu to Keiskamma Water Management Area)
SRK
No 1565

The Karoo rocks outcrop over almost three quarters of South Africa and act as a host for an important groundwater resources. Hundreds of villages in the rural areas of the Eastern Cape and KwaZulu-Natal provinces obtain their water supplies from boreholes adjacent to or within the area of influence of dolerite dykes and sills, which have intruded the Karoo sediments. These conditions produce s unique and complex hydrogeological system, which complicates the study and the development of groundwater. This project aims to:

- Conceptualise flow dynamics and groundwater flow paths
- Determine recharge-discharge and storativity and generate target maps for groundwater exploitation.

Estimated cost: R3 400 000 (KSA1)
Expected term: 2005-2009

Refining tools for evaporation monitoring in support of water resource management
CSIR
No 1567

Evaporation, after precipitation, is the largest component of the hydrological cycle at the land surface. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the transpiration of plants. There are many compelling water-resource related reasons (among them demands created by recent water legislation) for being able to measure/estimate and monitor evaporation with sufficient accuracy and precision. While many potentially suitable techniques and methods exist, there is a lack of knowledge regarding their appropriate use and capacity in applying them. Consequently, this project will aim to:

- Classify and characterise land uses/units and water-resource management applications for which evaporation measurements/estimates are needed
- Assess accuracy and precision requirements relating to evaporation measurement/estimation for various water resources.

Estimated cost: R1 600 000 (KSA1)
Expected term: 2005-2008

The freshwater requirements of temporarily open/closed estuaries on the South Eastern and South Western Cape coasts
SAIAB
No 1581

This project is the result of recommendations of a CERM strategic planning meeting held in March 2004 and is a multifaceted project in order to answer the generic questions routinely posed during DWAF RDM workshops.

Estimated cost: R1 753 000 (KSA 2)
Expected term: 2005-2008

National Wetland Rehab Programme Phase II: Wetland Health & Integrity
University of Cape Town, Zoology Department
No 1584

This solicited project is Phase 2 of the 3-phase National Wetland Research Programme and it focuses on the development of methods to assess the health and integrity of wetlands. The assessment of wetland health and integrity lags behind that for rivers and estuaries and this poses a problem in the environmental water determination process. There is also growing recognition of the important role of the ecosystem services provided by wetlands. A suite of assessment techniques is required not only to assess the ecological condition of the wetland but also the state of the services delivered. To that end, research

undertaken during this project will address the development of tools to assess the ecological condition a s well as the state of the services delivered, and to develop a protocol to gauge the loss of wetland function through degradation. Training courses and a communication programme will be developed to assist in the transfer of the technologies developed.

Estimated cost: R3 450 000 (KSA2)
Expected term: 2006-2010

Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa
University of Johannesburg (RAU)
No 1586

Ninety-seven per cent of the world's freshwater is subterranean, and there is an increasing demand for the development of this resource to meet the increasing needs of the population. Little is known about the stygobiont fauna or the interaction between underground and surface water. During this project the following aims will be addressed:

- Formulate a framework to characterise the geological occurrences and geographical distribution of the subterranean amphipods using GIS techniques
- Discussion on the applicability of the sampling protocol
- Identifying microbial composition in association with stygobiont amphipods
- Trace of inorganic macro-elements for water quality
- A primary framework development for the characterisation of groundwater systems.

Estimated cost: R1 350 000 (KSA 2)
Expected term: 2005-2008

Environmental water requirements in non-perennial systems
University of the Free State
No 1587

Methods for the determination of environmental flows for the Reserve have been developed and used for rivers with permanent flow. However, many rivers in the semi-arid west of the country are ephemeral. The NWA requires that the Reserve be determined before licences may be issued, and currently used methods have not been verified for ephemeral rivers. Verification needs to be done and, where necessary, new methods developed.

Estimated cost: R3 000 000 (KSA 2)
Expected term: 2005-2007

Development of a diatom protocol for river health assessment
DH Environmental Consulting
No 1588

Increasingly, diatoms are finding their place in the suite of water quality assessment tools available elsewhere in the world. The collection on which this project will be based spans a half-century, and the information that may be gleaned is potentially very valuable. A diatom assessment protocol (DAP) for river health assessment will be developed during this project, and this process will happen in three distinct phases.

In phase 1 a South African diatom taxonomic identification key will be developed, and diatom images will be transferred from the SA Diatom Collection onto electronic format. In Phase II the DAP protocol will be comprehensively tested to compare it with SASS indices within the River Health Programme, and there will be user training. It will also be linked to a central reporting database by means of a software resource centre before being calibrated, refined and released for wider use. Phase III will involve the continuing extraction of historical water quality and information on ecosystem condition from the SA Diatom Collection.

Estimated cost: R292 000 (KSA1)
Expected term: 2005-2006

Biochemical processes in a groundwater-fed inter-tidal ecosystem: Biogeochemical controls on the plant biodiversity within a salt-marsh ecosystem in the West Coast National Park: Impact of saltwater-groundwater interaction on pore water chemistry and vegetation
University of Cape Town, Geological Sciences
No 1591

The relationship between groundwater and surface water is poorly understood and the relationship between groundwater and the marine environment is even less well understood. However, the impact of poorly managed groundwater exploitation on the latter would have a severe impact on the ecology of the system. The groundwater-seawater mixing process impacts the salinity, anoxia and water movement, bioturbation and nutrient availability in the sub-surface coastal environment thereby controlling the distribution of halophytes and freshwater loving plants and any change in this balance will reverberate through the ecosystem. Over exploitation of the groundwater resource will have this effect.

This project aims to investigate this relationship in the West Coast National Park, an area of low rainfall and permeable geology where the Langebaan Lagoon is situated, which is primarily a groundwater-fed estuary. The area is undergoing development and so the demand for exploitation of the groundwater is increasing. This research will refine the understanding of the groundwater discharge around Langebaan, generate water quality maps, and identify any relationship between plant species and geohydrological characteristics. It will also identify specific characteristics which may be used in a monitoring programme and make recommendations on environmental water requirements of the area.

Estimated cost: R397 400 (KSA2)
Expected term: 2006-2008

Conservation model for threatened fish species
School of Agricultural & Environmental Sciences, Aquaculture Unit, Limpopo University
No 1677

Freshwater ecosystems are recognised as the most threatened ecosystems worldwide, and in an inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of habitat, are generally more sensitive to disturbance than invertebrates. The three main threats are from habitat loss, impact of aliens and exploitation.

The objective of this project is to develop a conservation model for threatened fish species using *Opsaridium peringueyi* as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170 (KSA2)
Expected term: 2006-2008

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface and groundwater
University of Pretoria
No 1686

The adverse effects of EDCs in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. According to the feedlot association of SA, 75% of all bovine produced in SA stems from the feedlot production system. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In SA no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal. In this study the presence/absence of veterinary drugs in the effluent of a number of feedlots would

be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources close to identified feedlots in South Africa screened for estrogenic and anti-androgenic activity, using a battery of bio-assays.

Estimated cost: R1 900 000 (KSA1)
Expected term: 2006-2010

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Industry-government partnerships for the development, setting and implementation of standards for the water environment
PBAI Associates
No 1416

The aim of this project would be to develop a partnership approach between industry and government for setting of agreed environmental standards, based on the Dutch 'covenant' model and utilising the provisions of the National Water Act for setting minimum standards for water uses which impact on the water environment, and implementing these through the use of provisions for environmental cooperation agreements which are contained in the National Environmental Management Act. The approach would be to work at pilot scale for one industrial sector and one aspect of the water environment, in order to develop a generically applicable model.

Estimated cost: R200 000 (KSA1)
Expected term: 2004-2006

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development
Conningarth Economists
No 1570

With water being a limited resource it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well- intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000 (KSA1)
Expected term: 2005-2008

Enriching freshwater conservation planning and management
CSIR, Environmentek
No 1678

The pressures from social-economic aspirations have resulted in a progressive degradation of freshwater habitats in recent decades. As in other countries, this country's rivers have deteriorated faster than terrestrial habitats. Ad hoc conservation efforts are not effective in the face of this pressure; a strategic and systematic approach is needed if the initiative is to be effective.

This project is part of a suite of initiatives (funded by WRC, DWAF and CSIR) which include the development of cross-sectoral policy and planning tools for conservation planning, and aims to advance our understanding of the relationships between freshwater conservation planning and the socio-economic and political processes that govern freshwater conservation at international, national and sub-national levels. This will be done through engaging the broader socio-economic and political discourse to identify the issues that are important for the successful implementation of the conservation planning process, and incorporating these into the overall process. This will be tested in a specific geographic context.

Estimated cost: R450 000 (KSA2)
Expected term: 2006-2008

A philosophy and strategy enabling learning for good ecosystem governance
CSIR
No 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. It also aims to develop a strategy and implement it using the above principles in pilot areas. As a new emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200 (KSA1)
Expected term: 2006-2009

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

Determine the applicability of ecological informatics modelling approaches for South African conditions with preliminary testing on algal blooms
School for Environmental Sciences, University of the North West, Potchefstroom
No 1675

Ecological informatics was formalised as a discipline in 2004 and is defined as interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing at and between all levels of complexity of ecosystems for use as a decision-making tool. Cyanobacterial blooms pose an ongoing problem in the water treatment industry, and there is currently no way of forecasting events, with planning being based on past experience. The ecological informatics approach is being developed, with some early success, for the forecasting of cyanobacterial blooms in Australia.

The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use based on the technologies used in Australia for use by water resource managers and water treatment works.

Estimated cost: R225 000 (KSA 2)
Expected term: 2006-2008

Periphyton flow dynamics
University of Cape Town, Zoology Department
No 1676

Periphyton (benthic algae) in rivers is highly sensitive to changes in both water quality and flow. Periphyton forms the base of the riverine food chain and any change at this level will be reflected throughout the ecosystem. In addition, the growth of undesirable periphyton can have negative economic consequences in several ways. Filamentous algae can clog irrigation and water purification equipment as well as rendering the habitat unfit for sensitive organisms, blue-green algae can cause toxin, taste or odour problems and any excessive algal growth will reduce the recreational value of the water body. Knowledge of the dynamics of the relationship between water quality and flow on the one hand and the response of the periphyton on the other will enable more accurate prediction of this response, and this capability is required in the determination of the Ecological Reserve.

During this project understanding of the interrelationship between periphyton growth and water quality/flow will be developed to a point where preliminary predictions can be made, and this

knowledge will be transferred to managers involved in determination and implementation of the reserve.

Estimated cost: R1 000 000 (KSA2)
Expected term: 2006-2009

NEW

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

The potential of food-web manipulation for the restoration of eutrophic South African impoundments
DH Environmental Consultants
No 1643

The project will address the challenge of eutrophication through the application of food-web manipulation as a cost-effective management option for South Africa's indubitably most limiting natural resource- fresh water. Many South African waters subsist in an advanced state of eutrophication, viz. a plagioclimatic condition dominated by a few taxa of coarse phytoplankton and fish. Such systems are resilient to remediation and require shock treatments such as the rapid bulk removal of problematic fish to allow the system to reset. In South Africa, eradication of common carp was seen as the first step in rehabilitation of most dams with eutrophication problems because it is this alien fish that prey on zooplankton, feed on open waters among macrophytes, and contributes to sediment disturbance and water column turbidity. The project will develop a scientific understanding regarding the storage vessels (dams) that largely supply all water user sectors (industry, agriculture, and domestic supply). The aims of this study are: to determine fish assemblages at a suite of impacted and control dams in the same eco-region, coupled with identification of trophic state and eutrophication impact assessment; to determine harvesting requirements to reset the fishery to a desirable assemblage; and to determine harvesting requirements to sustain the desired assemblage; to collect data on specific abiotic and biotic components (stable isotopes, phytoplankton and zooplankton assemblage).

Estimated cost: R1 727 760 (KSA 2)
Expected term: 2007-2010

To investigate the capability of the Mfabeni Mire (St Lucia) to respond to climatic and land-use stresses and its role in sustaining discharge to downstream and adjacent ecosystems
University of KwaZulu-Natal, School of Environmental Sciences
No 1704

The relationship between groundwater and surface water is important and not well understood. The Mfabeni peatland (at 1 250 ha one of South Africa's largest and at ~45 000 years before present (BP) one of South Africa's oldest peatlands) is situated on the East shore of Lake St Lucia within the Greater St Lucia Wetland National Park. The water from this wetland flows into Lake St Lucia where it provides freshwater refugia for biota in times of drought. During times of climate change wetlands such as this will potentially become more important for maintaining the biodiversity of Lake St Lucia and other similar systems. The research undertaken during this project will quantify the water balance of the peatland, the contribution of fresh water to Lake St Lucia and evaluate the effects between groundwater and surface water elsewhere and give guidance in managing this.

Estimated costs: R 1 123 391 (KSA2)
Expected term: 2007-2010

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment
Rhodes University, Institute for Water Research
No 1706

Scientific research has shown that all major aquatic wildlife groups are experiencing endocrine disruption (ED). ED, at many sites, is caused by a complex mixture of substances, very often in low concentrations, but acting in synergy with other compounds in the mixture.

Imperfect knowledge about the effects of endocrine disrupting compounds (EDCs) on ecosystem structure has implications for environmental risk assessment for EDCs. An important emerging approach is to develop models for ED exposure in food chains, including pathways for human exposure. This study will research and design a conceptual risk assessment model related to the unique features of EDC dynamics in the aquatic environment in South Africa.

This project aims to assess the advances made in the development of ecological-based risk assessment models and the use of the precautionary principle (vs. weight of evidence) in ecological risk assessments, as well as associated data requirements, with particular reference to EDCs. An appropriate ecological risk assessment model or framework for application in South Africa will then be recommended. The results will add value to the existing EDC programme and will provide guidance regarding future research. The results will add value to the existing EDC programme and will provide guidance regarding future research.

Estimated cost: R1 099 415 (KSA 2)
Expected term: 2007-2010

Influence of catchment development on peak urban runoff
UP
No 1752

Developments in urban and informal areas are regulated with regard to the potential flooding by the National Water Act (Act 36 of 1998). The 1:100 year flood line is used to define the extent of the development. Furthermore it is required by the municipal authorities that all developers should create temporal storage if the development contributes to the increase of the flood peaks. This study will provide a quantification of the influence of a catchment development on the flow rate and volume of runoff. The study will contribute to an effective stormwater drainage design and optimisation of costs for the upgrade of hydraulic infrastructures in targeted urban areas.

Estimated cost: R665 000 (KSA 1)
Expected term: 2007-2010

Land-water linkages: Agent-based modelling of land-use change and its impact on water resources in the Modder River basin
Central University of Technology, Free State
No 1753

Changes in land use have profound impacts on water resources. This study applies agent-based modelling to investigate land-use changes and how these impacted on water resources in the Modder River basin. While previous studies of land-use changes have addressed simplistic representations of two or three driving forces, the agent-based modelling technique will involve several situation-specific interactions among a large number of factors at different spatial and temporal scales. The main objective of this research project is to analyse land-use changes and highlight the dynamic nature of coupled human-environment systems using agent-based modelling in relation to land-use change and its impact on water resources.

Estimated cost: R357 000 (KSA 1)
Expected term: 2007-2010

A national survey of mercury levels in South African resources
CSIR
No 1754

Recent estimates indicate that Hg emissions from sources in South Africa, mostly coal combustion and gold mining, contribute with more than 10% to the global Hg emissions, thereby ranking the country second after China, on the list of major Hg polluters globally. Mercury (Hg) pollution is a worldwide problem that should be addressed at global, regional and national levels. Mercury is released into the atmosphere from anthropogenic sources both as elemental Hg (Hg0) and ionic oxidised (HgII). The major concern with Hg0 is that once released to the atmosphere, it is oxidised contributing to the oxidised Hg pool. This HgII is very water-soluble, and is removed from the atmosphere by both wet and dry deposition and enters freshwater and marine resources, where it is rapidly converted into the more toxic methyl-mercury (CH3Hg) form. This more toxic form bio-accumulates in the aquatic food chain and poses a serious health risk to humans who consume fish or other aquatic organisms that are contaminated with CH3Hg.

Anthropogenic activities such as artisan gold mining activities, industrial and small-scale coal combustion, as sources of Hg to the atmosphere, its deposition to water resources and its effects on water quality are not well characterised in South Africa. Accordingly, as one important step towards such characterisation, this proposal aims to carry out a national survey of Hg levels in South African water resources. This should provide a sound basis for establishing the extent to which Hg is currently a problem in South Africa. The aims of the study are to survey the levels and speciation of mercury in water, sediments and biota in priority South African water resource; to assess the degree of compliance of the measured mercury levels with national and international guidelines; to assess the degree to which mercury may be a problematic pollutant in South Africa; and to create local capacity relating to mercury sampling and analysis.

Estimated cost: R918 850 (KSA 1)
Expected term: 2007-2009

Water quality monitoring data and target users: Maximising value
CSIR
No 1755

DWAF operates a vast water quality monitoring network. The information transfer which should form an integral part of the design of such networks is not functioning optimally at present. Much of the value of water quality information is lost if it is not effectively conveyed to users. This project will aim to maximise the value of water quality monitoring programmes by optimising the way in which information is transferred to users. This could have a knock-on effect regarding the appreciation of water quality management by politicians and the man in the street.

Estimated cost: R488 960 (KSA 1)
Expected term: 2007-2009

Implementation of ecological hazard assessment of industrial waste discharge at local municipal level, comparing toxicity test methods
Rhodes University
No 1757

The existing duality and debate on water as being both an economic and a social good, places a special in the complex chain of supply of water resources, especially to the poor in South Africa and the financial implications thereof. The daunting task for municipalities to supply affordable water, refrain from cutting connections and make the service sustainably available to all still remains to be a dream. If the ultimate goal is reducing poverty by 2015, it is very difficult to ignore the backward and forward linkages to making water available. New introductions of WRM charges and new CMAs will have cost implications. Overall, decentralisation is thought to make services more relevant and affordable, the project will test this hypothesis and make future recommendations on the appropriateness of pricing water in South Africa, especially for municipalities and agricultural sectors. The project will highlight areas for further research to assist in the implementation of financial arrangements; provisions, support, subsidies, etc. to poor water users.

Estimated cost: R200 000 (KSA 1)
Expected term: 2007-2008

Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater
UFS
No 1766

The programme outputs will establish an improved understanding of the origin of pollutants, the pathways which these pollutants could follow into the environment and the ultimate fate of these pollutants (LNAPLs). This project will produce tested techniques and guidelines for application in the industry. Available approaches are usually based on international case studies dealing mostly with porous aquifers. South African specific case studies will enable a better understanding of the behaviour of LNAPLs in the subsurface with a specific emphasis on fractured rock environments.

Estimated cost: R3 500 357 (KSA1)
Expected term: 2007-2011

Investigation of the positive and negative consequences associated with the introduction of low-P detergents
University of KwaZulu-Natal (PMB)
No 1768

Eutrophication is rated as one of the major water quality problems being experienced by South Africa. Eutrophication, in specific the accumulation of phosphorus (P), gives rise to serious problems with the water quality management of South African dams. It is estimated that up to 50% of P in South African sewage comes from detergents. This project will investigate the positive and negative consequences that the introduction of detergents with lower P contents would have on the eutrophication of dams, users of detergents, water and waste water treatment works and the waste discharge charges system.

Estimated cost: R689 200 (KSA 1)
Expected term: 2007-2009

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity
CSIR Natural Resources and the Environment
No 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision making in a situation of varying levels of certainty and of potential conflict. Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820 (KSA 2)
Expected term: 2007-2010

Guidelines for the utilisation and disposal of water treatment residues
Golder Associates Africa (Pty) Ltd
No 1723

WRC Project No 1148 found the disposal of water treatment residues (WTR) to land could have positive

effects. No local guidelines for land disposal exist at present. In order to determine what information is still required to develop such guidelines, a follow–on project (**No 1601**) produced a scoping report on the development of guidelines for the land disposal of WTR. Although a number of knowledge gaps remain, this new study will develop guidelines based on the best current local and international information. The objective is to revisit these guidelines after 5 to 10 years of application and include actual field data and experience gained during this period. A national survey will determine the variation in the characteristics of different WTRs. The previous research and survey data will be used to develop guidelines that describe the requirements for the land disposal and agricultural use of WTR. A stakeholder consultation and scientific peer review process is planned to gain broad acceptance for the guidelines.

Estimated cost: R746 820 (KSA 3)
Expected term: 2007-2009

Development of guidelines for urban Metros to facilitate legal compliance with respect to industrial waste management
Nancy Oosthuizen Consulting
No 1733

eThekwini Metro have recognised that better waste management practices should be achieved as ineffective waste management practices are impacting negatively on cities' water resources. This case study aims to develop a set of easy to interpret, laymen's guidelines aimed at industry, ports, intermediate waste contractors to achieve legal compliance related responsibly managing wastes to achieve legal compliance. The products will not only benefit eThekwini, but all large metros and coastal cities as well.

Estimated cost: R350 000 (KSA 3)
Expected term: 2007-2008

Protocol for quantitative assessment of industrial effluents for discharge permitting
University of KwaZulu-Natal
No 1734

Local authorities manage industrial wastewater using its wastewater treatment plants for remediation, by issuing discharge permits with limits on discharge, and a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system. An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000 (KSA 3)
Expected term: 2007-2011

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water
CSIR
No 1749

The Department of Water Affairs and Forestry is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles where used in the 1996 South African Water Quality Guidelines (Vol 6: Aquatic Environment) the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in characterising the biotic effect of various endocrinal active substances at various levels of biological organisation, critical interpretational gaps remain. In its commonly used paradigm, health risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water.

The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500 (KSA 3)
Expected term: 2007-2009

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

Environmental assessment in an area where ongoing DDT spraying occurs
Rhodes University, Institute for Water Research
No1708

Previous research at Rietvlei Dam, (**Project No 1505**) identified a number of possible EDCs. DDT was a major contributor in many of the samples analysed. In Limpopo Province and KwaZulu-Natal, DDT is used for malaria control, and higher environmental levels were expected in studies there.

This research will add value to the variables being investigated by **Project No 1674** in the Limpopo Province. The data will also contribute to the risk assessment to be undertaken in the same area.

Several invertebrates and vertebrates will be examined for the effect of DDT.

Estimated cost: R398 330 (KSA 2)
Expected term: 2007-2008

Sedimentation and sediment yield maps for South Africa
US
No 1765

Loss of storage capacity in of dams due to sedimentation is a major strategic threat to our country's available water resources. Soil erosion and therefore sediment yield and reservoir sedimentation is accelerated by human activities such as clearing of vegetation and poor farming practices. In order to regulate and manage these negative actions, it is important to have accurate national maps of eroded areas and sediment yield. The sediment yield maps to be developed in this project are expected to assist the Department of Water Affairs and Forestry in mitigating sedimentation impacts and making adequate provisions for sedimentation in dam developments. The better understanding of localised sedimentation process from this research will feed into the land and soils conservation and management practices which are major concerns in farming communities and the national Department of Agriculture.

Estimated cost: R1 400 000 (KSA 1)
Expected term: 2007-2010

South African Handbook on Environmental Hydraulics
Ninham Shand
No 1767

A great deal of river hydraulics knowledge has been gained through WRC projects. In the past research projects have addressed a number of subjects which included: flow hydraulics, sediment transport and deposition which are cornerstones of environmental studies. The knowledge gained from WRC research has been accumulated into a number of research reports, some of which are no longer available for distribution. This project will seek to collate available knowledge and experiences and integrate these into a user-friendly handbook of river hydraulics. The project will engage several experts to contribute on their specific research areas.

Estimated cost: R920 000 (KSA 1)
Expected term: 2007-2009

THRUST 4: ENVIRONMENTAL DEGRADATION AND MITIGATION

The development and testing of a coherent, integrated and practicable set of indicators for the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation
Association for Water and Resource Development (AWARD)
No 1709

Indicators provide a method for presenting information in a standard way that can be monitored and used to measure change. The wetlands in the communal areas are important resources which provide livelihoods for many of the poor people in the area. While the land tenure system in is not conducive to the exercise of close control of practices, these wetlands do form part of the national water resource and South Africa's IWRM policies require the integration of the many components of the water resource.

Research done in this project will develop and test a coherent and practicable set of indicators for an integrated approach to the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation.

Estimated cost: R236 100 (KSA 2)
Expected term: 2007-2008

Refinement of the decision support system for metalliferous tailing disposal facilities
Golder Associates Africa (Pty) Ltd
No 1735

Project No 1551 developed a first-order decision support system (DSS) for the sustainable design, operation and closure of metalliferous tailing disposal facilities as part of a long-term programme to deal with these facilities on a sustainable basis. This follow-on project will refine the first-order DSS by developing guidance and support to demonstrate that the environmental impacts on the surface stability and water aspects are acceptable and to identify new and promising technologies and approaches.

Estimated cost: R2 200 000 (KSA 3)
Expected term: 2007-2009

Consideration of the impact of classification and landfilling of hazardous waste
CSIR
No 1736

The minimum requirements for general and hazardous waste have been in place for over a decade. A systematic assessment is needed to determine whether the desired groundwater protection has been achieved, particularly at sites that have received delisted wastes. The assumptions made in the delisting process (i.e. whether they are conservative or not) and those against field data from operational landfills. Further, the impact of the disposal of hazardous waste on leachate quality and landfill processes is required. This study aims to begin the process, by considering the impact of selected delisted hazardous or industrial waste on a selection of landfill sites. The study includes an assessment of leachate quality from a selection of general waste landfill sites that receive hazardous waste compared to those that do not to validate the assumptions made in the delisting process and determining the extent to which a selected hazardous waste type impacts on leachate quality.

Estimated cost: R800 000 (KSA 3)
Expected term: 2007-2009

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WATER AND HEALTH

Dr Gerhard Offringa | Head | Retired 31 March 2008

SCOPE

Water-related health forms a crucial and integral component of our daily quality of life. Health-related water research is undertaken with the aim of improving water quality and hygiene practices in order to save lives and reduce the cost and effort in treating diseases and their symptoms.

The Water and Health Impact Area continues to play an essential role in providing an integrating framework for all the WRC's health-related research and development initiatives, identifying gaps and negotiating the initiation of gap-filling research in crucial areas. In fulfilling this role, the Impact Area assumes the responsibility for the structuring of a coordinated, needs-driven, dynamic health-related water research portfolio on behalf of the WRC, with contributing projects being funded and managed in the appropriate KSAs.

The focus is on water-linked health impacts associated with microbial or chemical contamination or transferred via water-associated vectors. The Impact Area aims to improve knowledge regarding the origin, survival and persistence of microbial, biological and chemical agents that may pollute water and may affect human health. The Impact Area supports the development and utilisation of methodologies to identify and quantify the occurrence of pathogens and contaminants in water, as well as risk assessment and epidemiological studies.

A holistic, multidisciplinary approach is followed in order to develop a comprehensive understanding of the origin/sources and spatial extent of pollution; water usage patterns; the effects of degraded water quality on human and animal health and the need for, and efficiency of, various water treatment options. The development of guidelines, protocols, manuals and pamphlets as tools to disseminate research findings is supported. The emphasis is on a pro-active approach to identify and address causes, rather than on a passive response to addressing symptoms. This approach should ensure research products that are relevant, user-friendly, practical and scientifically valid.

OBJECTIVES

The primary objective of this Impact Area is to contribute to the protection of human health by investigating the sources, occurrence, persistence and control of water-related diseases and other water-related health problems.

Secondary objectives are to:

- Develop appropriate techniques, technologies and systems for monitoring of potentially harmful pollutants in water
- Obtain adequate understanding of the origin, survival and persistence of, and inter-relationships between, microbial, chemical and other biological and toxic pollutants in water
- Assess the impacts (actual and potential) of pollutants on human health by performing epidemiological investigations and developing health-risk assessment tools
- Investigate the effects of the environmental change on health (e.g. the impact of global warming on the spread of malaria; the link between climate variability and epidemics caused by water-borne diseases)
- Develop scientifically sound educational material on health, hygiene, the effects of pollution and the prevention of pollution, and the relationship between these
- Provide guidance for appropriate communication, awareness-building and management strategies
- Contribute to the general health of animals and of the environment in pursuing all of the above objectives.

THRUSTS

Following the completion of the Strategic Framework for Water Related Human Health Research, finalised at the end of 2005, the past year (2006/07) was the first year in which the Impact Area operated under the new thrust areas. For 2007/08 these thrust areas are the following:

THRUST 1: RESOURCE PROTECTION

The focus of research under this thrust is on the safeguarding of human health through the protection of both surface and groundwater resources from impacts that compromise the quality of water and add to the economic burden of treating water to the national water quality norms and standards. Point and diffuse sources of pollution are addressed through pollution prevention interventions and remediation where water quality has already deteriorated. The focus is on the detection, prevention and management of all contaminants that pose a threat to human health. Development of health risk assessment and management tools for protecting human health from water-related health hazards is addressed under this thrust.

Research under this thrust is addressed under the following programmes:

Programme 1:	*Detection, prevention and management of water-related microbial agents*
Programme 2:	*Detection, prevention and management of chemicals and radioactive contaminants in water resources*
Programme 3:	*Management of eutrophication and algal toxins*
Programme 4:	*Management of impacts of land-use activities on surface and groundwater at a catchment level*

THRUST 2: DRINKING WATER

This thrust focuses on research addressing all health impacts of drinking water quality, risk assessment and risk management approaches such as water safety plans and the development of water quality monitoring systems. Research is contributing to ensuring that drinking water is safe, i.e. it does not cause any harm to human health, and it is free from pathogens and chemical contaminants that can potentially induce pathological and physiological damage to humans. This is achieved through the development of rapid and sensitive technologies for detecting contaminants in drinking water and innovative treatment technologies for removing contaminants from water. Research also contributes to the development of effective governance systems which are necessary to facilitate the regulation of drinking water quality.

Research is addressed under the following programmes:

Programme 1: *Drinking water quality management*
Programme 2: *Water treatment technologies and reticulation systems*

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

This thrust focuses on proximal factors such as water quantity, health and hygiene education that have a direct link to disease transmission. It also addresses the distal causal factors such as socio-economic factors that have an impact on both the health of a society and the individual through the linkages to the proximal factors. Public health protection has the following components:

- Surveillance to measure risk associated with specific water uses
- Comparisons of measured risk and predefined acceptable risk, thus leading to the development of control strategies
- Public awareness campaigns and promotion of sanitation, health and hygiene education.

The main focus of this research thrust is on the development of tools for the identification of conditions that are conducive to water-borne disease outbreaks and appropriate precautionary and preventive measures that can be taken to protect public health. Examples of tools include water quality monitoring systems, early warning systems, disease surveillance systems and health and hygiene awareness and education materials. The impact of sanitation, water quality and quantity on the health of HIV/AIDS patients is also addressed with a view to developing strategies for reducing their exposure to microbial agents associated with contaminated water. Capacity building and training of sector professionals is receiving attention under this thrust because the availability of skilled personnel is critical to public health protection.

Research is addressed under the following programmes:

Programme 1: *Public health, hygiene awareness and educational materials*
Programme 2: *Capacity building and training programmes for public health professionals and practitioners*
Programme 3: *HIV/AIDS linkage with water quality and quantity and access to adequate sanitation services*
Programme 4: *Impact of water quantity and service levels on human health*

THRUST 4: SANITATION AND WASTE MANAGEMENT

This thrust focuses on health aspects of the different sanitation technologies and waste management practices, with special reference to health implications of using waste as a resource. Promotion of ecological sanitation technology is leading to a growing interest in the use of human excrement and grey water in crop production. There is a need to find a balance between increasing food security for poor households and the protection of public and environmental health. Research provides scientific information and health risk management strategies for guiding decision makers in setting minimum quality standards for use of wastewater in crop production in order to protect human health. Research addresses safe treatment and disposal of sludge from on-site sanitation systems, for example, pit latrines, septic tanks and urine diversion systems. Health implications of malfunctioning water-borne sewerage and poor storm drainage systems are also addressed under this thrust.

Research is funded under the following programmes:

Programme 1: *On-site sanitation treatment technologies*
Programme 2: *Use of waste as a resource*
Programme 3: *Management of water-borne sewerage and stormwater systems*

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Research under this thrust focuses on the health implications of other water uses such as health risks associated with the irrigation of crops with water of poor quality; polluted recreational waters; and occupational exposure to water of poor quality. Irrigation of crops with water of poor quality can have both direct and indirect effects on human health. Health risk assessment studies for the different use categories should be undertaken and appropriate management strategies should be developed to mitigate negative health impacts of exposure to water of poor quality.

Research is addressed under the following programmes:

Programme 1: *Impacts of quality of irrigation water on human health*
Programme 2: *Ensuring safe water for recreation*
Programme 3: *Management of health impacts associated with occupational exposure to water of poor quality*

THRUST 6: GOVERNANCE SYSTEMS FOR SAFEGUARDING HUMAN HEALTH

This thrust focuses on research that supports the implementation of the basic principles of effective governance (stakeholder participation, transparency, equity, accountability, coherence, responsiveness and integration) within the context of water and human health. The research contributes to the development of a regulatory framework for the protection of public health from all water-related health impacts. It also develops tools and guidelines for the implementation of comprehensive risk management strategies for managing drinking water quality from the catchment to the end-users. Research necessary to evaluate and guide the policy formulation process is addressed under this thrust. Models for appropriate governance systems that are necessary to support effective regulation of water quality, are addressed. These models should be flexible enough to accommodate the challenges faced by small water service authorities with regard to water quality aspects.

Research is undertaken under the following programmes:

Programme 1: *Governance system for the protection of public health from water-related impacts on human health*

This programme focuses on governance issues that should be addressed to safe guard public health from water-related impacts on human health.

Programme 2: *Regulatory framework for an integrated water quality management approach*

This programme addresses governance issues pertaining to the protection of the resource, focusing on the development of appropriate instruments and tools for regulating integrated water quality management and enforcing compliance.

Research portfolio

The funding for research projects relevant to this Impact Area and supported by the various KSAs, is estimated at R9.8 million for 2007/8. Of this, R6.5 million is for ongoing research and R3.3 million for approved new projects. The spending on new projects in this Impact Area is substantially lower than in 2006/07, where R6 million was allocated.

This is attributed to the high budget requirements of this large number of projects currently running, leaving little money available to initiate new research.

RESEARCH PROJECTS FOR 2007/8

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2007 and 31 March 2008.

COMPLETED

THRUST 1: RESOURCE PROTECTION

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

Programme for endocrine disruption contaminants (EDC)
Consortium Members: US; UFH; MEDUNSA; Technikon Free State; Technikon Pretoria; SABS; Environmentek, CSIR; ARC-PPRI; Consultant manager
No 1402

EDCs are defined as chemicals that interfere with the structure or function of hormone-receptor complexes. EDC research requires a multidisciplinary approach involving research in disciplines such as zoology, physiology, toxicology and analytical chemistry to be able to assess the risk to the human and wildlife populations and the state of contamination of the water resources. In the strategic EDC research report (**Volume 1**) a survey was conducted on the state of the science in South Africa and existing data was evaluated.

This report is the first phase of the implementation of the programme (**Volume 2**) and includes capacity building in research facilities to do EDC activity testing as well as chemical analysis. A limited surveillance study was conducted at four selected sites during four sampling events.

The results of the different laboratories participating in the study are summarized and presented in this report. Water and sediment samples were analysed for pesticides, minerals and industrial chemicals. Hormone analysis was only conducted on water samples. All the individual reports of the participants are on the CD attached to the report.

Recommendations for future research needs and updating of the strategic research programme were made.

Cost: R3 000 000
Term: 2002-2007

To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater
Council for Geoscience
No 1431

The overall objectives of the project are to provide a basis for the South African authorities to safeguard groundwater consumers from exposure to toxic trace elements, and to determine whether or not leach testing on representative bedrock, or reliable geochemical models can be used to predict natural groundwater contamination in different regions. The trace elements of interest in this project are arsenic, chromium and uranium. The field investigation sought to sample a broad range of geological settings across South Africa and covered the following regions:

- Giyani and Gravelotte greenstone belts
- Eastern Bushveld
- Rooiberg tin fields
- Karoo coal fields
- Bushmanland
- Beaufort West and Sutherland.

The field investigation made the following main findings:

Arsenic was measured in harmful levels in one Giyani and three Beaufort West boreholes. Only one farm borehole was among this group (in Beaufort West) and the rest were mining or exploration boreholes. There was potential for speciation of arsenic in the more toxic arsenite form (As III) at approximately 10% of boreholes, including the Giyani borehole above.
Chromium was not measured in harmful levels in any boreholes, although was present in low concentrations at most. There was potential for speciation in the more toxic hexavalent form (Cr VI) at only one Karoo coalfields borehole.
Uranium was measured in harmful levels in 13 boreholes in Bushmanland and Beaufort West, and at low levels in some others. The boreholes in the former region were mostly located on farms, whilst those in the latter included one farm borehole and two exploration boreholes. According to water quality guidelines, the uranium levels measured on the farms should not pose a threat to most healthy individuals.

In general the various leach tests on non-ore-body samples yielded relatively minor quantities of the contaminants of concern for the current study (As, Cr and U). Some higher levels of these metals were leached from some samples collected in mineralised zones; however, water in these areas would not normally be used for drinking purposes. Batch leach test results showed very weak, insignificant correlations with groundwater collected at corresponding sites, for all three elements of concern.

The leaching results support those of the geochemical modelling, in that the naturally elevated levels of hazardous trace elements in groundwater observed in field sampling are unlikely to be the result of simple interactions between groundwater and the surrounding aquifer material. More likely, it is the result of interactions within local mineralised zones within aquifers or recharge areas, or localised anomalous geochemical zones within aquifers.

Cost: R 900 000 (KSA1)
Term: 2003-2007

Occurrence and fate of EDCs in drinking water
CSIR
No 1532

Natural hormones, including estrogens, can be released into the environment via sewage effluent and from sources such as animal feedlots. Studies have shown that a number of EDCs (e.g. nonyl phenol, chlorinated pesticides, polychlorinated biphenyls (PCBs)) are present in South African surface water and effluent discharges. The presence of EDCs in drinking water sources is a matter of great concern and poses the question of how effectively these chemicals are removed by conventional water treatment methods. Due to the wide structural diversity of these chemicals, more than one process may be required for their removal. This pilot study was carried out to investigate the occurrence of oestrogen mimicking substances and estrogenic activity in the source and treated drinking water, in drinking water treatment plants using biological/biochemical techniques as well as its removal by different treatment processes and to make recommendations on the most appropriate combination of tests for the detection of estrogenic activity in drinking water.

A battery of *in vivo* and *in vitro* biological/biochemical techniques established by different South African and overseas laboratories were applied according to published protocols. Three drinking water treatment plants were selected for the study. Source water and water from selected treatment processes (e.g. flocculation, sand filtration, and chlorination) were tested over a 1 year period. The bioassays clearly showed estrogenic activity in source and treated drinking water. Chemical analysis also indicated that triazines and nonyl phenol were occasionally detected in water samples. The estrogenic compounds 17α- and β-estradiol, estrone, 17α-ethinylestradiol and estriol in all the water samples were below the detection limit of 1.0 ng/ℓ. The results obtained with the YES and ER-CALUX assay showed a reduction in removal of oestrogenicity by the water treatment processes. The most significant reductions were observed in the final waters, after chlorination. In general, both assays indicated some increase in estrogenic activity after the addition of flocculants. A

reduction of triazines and p-nonyl phenol concentration in final waters was also noticed during 50 to 75% of the sampling occasions. Factors such as heavy rain, high algal loads and changes in flocculant did not appear to have impacted on the water quality. What appeared to be an important factor in the efficiency of treatment plants to reduce and remove oestrogenicity was the source water quality. The YES and ER-CALUX and PRTH assays proved to be the most suitable for the detection of oestrogenicity in drinking waters. The *in vivo* tests did not perform well in the study. *In vivo* tests are time consuming and there are many variables that can impose errors in the assays. These tests are, therefore, not recommended for drinking water testing. In order to establish the cause of these effects, extensive chemical monitoring programmes are recommended. Risk assessment will also be required to provide answers on the risk involved in drinking water exhibiting oestrogenicity.

Cost: R830 000 (KSA3)
Term: 2004 -2006

Production of microcystin standards and evaluation of cyanobacterial hepatotoxin quantification methods and their relative suitability for screening and quantification
NMMU
No 1695

In the absence of a comprehensive survey of South African cyanobacteria that encompasses both distribution and diversity, no understanding of the dissemination and prevalence of toxic cyanobacteria is possible. The absence of a complete culture collection based on such a survey also precludes any general geographically or taxonomically representative analysis of South African cyanobacteria for any purpose. Additionally, expertise on the identification of cyanobacteria is extremely limited in South Africa and the development of a routine molecular identification facility coupled with and based on the molecular identification of culture collection material, would serve as a source of reference material for both training and cross referencing purposes.

One of the other major hurdles in cyanobacterial research and the management of cyanobacterial events, such as toxic blooms, is the continuing difficulty in obtaining commercial reference material for microcystins. The inconsistency in supply of microcystin standards for both identification of variants and quantification of toxins in water is compounded by the limited number of variants that are commercially available. Standards can take several months to obtain and some variants currently cost in excess of R25 000 /mg.

General screening for microcystins in water supplies is commonly undertaken by commercial ELISA kits. No evaluation of these kits in terms of comparison with other existing screening and analytical methods has been undertaken with purely novel isolates of unknown hepatotoxin content. Anecdotal evidence suggests false positives for both ELISA and protein phosphatase inhibition (PPi) assays but a comparison of these methods would require a study of efficiency of variant detection and certain variants are not commercially available. Additionally, no laboratory in the country currently performs HPLC, ELISA and PPi, and can do so on molecularly identified taxonomically diverse uni-algal South African isolates.

This project was therefore intended to initiate the development of a culture collection and set in place the methods and facilities to address the remaining fundamental issues for future research.

- To initiate the creation of a geographically and taxonomically representative cyanobacterial culture collection
- To establish full characterization protocols
- To optimise the laboratory scale production of microcystin standards
- To evaluate current microcystin screening.

The defined primary objectives were achieved. Specifically, a taxonomically and geographically representative culture collection of South African cyanobacteria was established. Characterisation of uni-algal cultures and production of axenic cultures as well as complete phylogenetic analysis has been started and is an ongoing project (WRC K5/1719). Additionally, laboratory scale microcystin standard production was optimised and microcystin screening methods were evaluated. Evaluation of screening method efficiency for different microcystin variants was not achieved because to date no isolate has been identified that produces sufficient quantities of toxin other than microcystin-LR. Thus laboratory scale production of variants other than microcystin-LR has not been done.

To date 368 uni-algal cultures are in the collection, including four axenic cultures. Cultures are in various stages of characterization and the information is currently available on an internal web-based database. Initiation of phylogenetic analysis using phase one of the sampling regime (Eastern Cape) yielded 16S rRNA gene sequence data for over 30 isolates suitable for analysis. Phylogenetic and phylogeographic analysis revealed reasonable genetic diversity but no geographic basis for the diversity. This suggests transfer of cultures between water bodies. Water scheme transfers were investigated but no downstream similarity could be detected. Increased resolution by sequencing of additional genes and genomic methods is indicated and this is currently being undertaken as is the continued analysis of isolated strains.

Protein phosphatase inhibition is not recommended for screening of water samples or isolated cultured strains, for the presence of microcystins or nodularin. The method is suitable for determining relative abundance of the toxin in a given strain where the method is optimized for that purpose. ELISA offers increased sensitivity for multiple variants and as such is a suitable water screening method which has been validated and verified and is currently in use. HPLC-PDA or HPLC-MS remains the industry standard and should be encouraged as the primary analytical method. Where raw water samples show positive results for ELISA, solid phase extraction of a sufficient volume should be undertaken prior to HPLC-PDA to ensure adequate concentrations given the possibility of multiple variants.

Ongoing maintenance and expansion of the culture collection has already been ensured by the WRC via NMMU where the culture collection is housed. Duplication of the culture collection has been started and duplicate cultures will be maintained at NWU (Potchefstroom) where further characterisation will also take place.

Full phylogenetic characterisation will also take place as a function of **WRC Project No 1719** and screening for both hepatotoxins and neurotoxins is ongoing. The creation of an online database as part of a central communications and data-sharing portal is essential for the full benefit of the culture collection to be realised and the creation of this facility has been started.

Cost: R250 000 (KSA1)
Term: 2006-2007

Programme 3: Management of eutrophication and algal toxins

Cyanobacteria programme: Toxin blooms and toxin promotion
Consortium members: PU for CHE; University of Port Elizabeth; Technikon Pretoria
No 1401 (b; c)

1401 (b)
Since many genera of freshwater cyanobacteria are capable of production of hepatotoxins, increase in the frequency and severity of bloom events poses a problem for potable water supply in that classical treatment methods result in cell lysis and release of these toxins. An understanding of the environmental conditions that modulate toxin production would therefore be beneficial to the management of potable water supplies. Definition of the primary parameters and a model of the mechanism of modulation of toxin production would further facilitate management and treatment.

The primary objective of this work was to determine the modulatory role of environmental orthophosphate and nitrate levels on microcystin production by the dominant microcystin producing genus in South African freshwater impoundments and to develop a model to describe the cellular mechanisms by which these environmental parameters modulate microcystin content.

The co-modulatory effect of environmental phosphorus was investigated because of the role of cellular phosphorus in photosynthetic carbon fixation, and the resulting effects on cellular C:N ratios and on nitrogen assimilation. The modulatory effects of carbon fixation: nitrogen uptake and cellular C:N ratios were also investigated in the absence of variation of growth rate so as to relate environmental N:P ratios to cellular activities. In order to further clarify any modulatory effects of these environmental variables, potential regulatory mechanisms were investigated. Specifically, the potential role of NtcA (a cellular nitrogen regulator) and the levels of nitrogen assimilation products and carbon precursors were studied so as to determine the cellular status of these constituents under environmental conditions leading to increased microcystin production, thereby attempting to elucidate the potential mechanisms by which the relevant environmental factors enhanced microcystin production.

Specific growth rates and protein and microcystin content of *M. aeruginosa* PCC7806 and M. aeruginosa UV027 were determined under non-limiting batch culture conditions for a range of medium nitrogen and phosphorus atomic ratios (N:P). Both strains exhibited a similar optimal medium N:P ratio for increased cellular microcystin levels. Additionally, total cellular protein content and intracellular microcystin content were significantly correlated. Microcystin and protein content increased considerably as the maximum specific growth rate for the experimental conditions was reached. The correlation between cellular protein and microcystin content and their relative increase with increasing specific growth rate occurred within defined ranges of medium N:P ratios. This suggests a close association between microcystin production and N:P ratio dependant assimilation of nitrogen, and resulting total cellular protein levels, which may be further modulated by specific growth rate.

Microcystis aeruginosa PCC7806 was grown in continuous culture with varying medium nitrate concentrations and sampled at steady states for analysis of cell numbers, microcystin content, cellular N and P, residual medium nutrient concentrations and carbon fixation rates. Cellular microcystin quotas showed significant positive correlation with both nitrate uptake and cellular nitrogen content, and were negatively correlated with carbon fixation rates, phosphate uptake, and cellular phosphorus. Thus the ratios of nitrate uptake to phosphate uptake, cellular N to cellular P, and nitrate uptake to carbon fixation were positively correlated to cellular microcystin. Microcystin quotas increased 10 fold between the lowest and highest steady state values. Contrary to what was previously reported, cellular microcystin content is therefore controlled to a significant extent by variables other than growth rate, with nitrogen being the most significant modulator. Batch culture in BG11 under identical conditions yielded increased microcystin when nitrogen uptake rate was relatively higher than growth rate, confirming the importance of nitrogen uptake in the modulation of microcystin content for a specific growth rate.

In conclusion, this work shows that the primary environmental modulators of MCYST production by *Microcystis* that are suitable for simple measurement, and use in predictive models, are environmental nitrogen and phosphorous and growth rate. However, given the complexity of the regulation of microcystin production and the strain variation in toxin production, it does not seem likely that a single general model will emerge that allows accurate long term prediction of toxin levels unless accurate nutrient loading and PAR forecasts are possible. Despite this, reasonably accurate short term prediction does seem possible, as does a general prediction on whether toxin levels will increase or decrease over periods possibly as long as one month. Work currently in progress includes the validation and refinement of these types of models on fed batch cultures of various strains and communities. Artificial neural network models also appear to hold some promise and should be further investigated. This work clearly shows the primary environmental modulators that should constitute the input nodes of such models and therefore substantially adds to the current knowledge base on predictive modelling of microcystin production. Similarly, the models presented here are the first reported models of toxin production based on environmental variables and as such constitute a major advancement in both the understanding of the regulation of microcystin production and the approach to both structured and a-posteri modelling of toxin production by *M. aeruginosa*.

Future work should be aimed at refining the model by large scale validation in fed batch reactors and inclusion of additional environmental parameters. Ultimately the model should be validated on a suitable impoundment and refined for use on that specific water body so as to evaluate the predictive potential of microcystin modelling based on nutrient loading.

1401 (c)

Cyanobacteria are a group of extraordinarily diverse Gram-negative prokaryotes. Problems may occur as a result of algal overgrowth and the production of toxins. This species periodically blooms in Hartbeespoort Dam, a popular recreational dam and a source of domestic and irrigation water in North West Province. Consequently, there was a need to conduct a study to assess the appearance pattern and persistence of the *Microcystis aeruginosa* in the Dam. The review examines numerous aspects that influence cyanobacterial growth in Hartbeespoort Dam, their persistence and various options that have been used to prevent and control the bloom. Critical among them include complex and dynamic relationships between physical, chemical and biological factors such as water temperature, pH, and nutrient availability (nitrogen, phosphorus, iron). Eutrophication problems, which often results from increased anthropogenic activities has been widely accepted as the main problem in Hartbeespoort Dam. The nutrients are continuously generated in the catchment areas draining into the dam and the load from Jukskei/Crocodile Rivers.

The primary aim was to investigate environmental factors that affect the occurrence, persistence and bloom formation of phytoplankton species with particular emphasis on the *Microcystis aeruginosa* in the Dam.

Water and sediment samples for algal identification and quantification and for the determination of selected chemical water quality parameters such as, nitrates, phosphates, sulphates and metals were collected fortnightly. The study also retraced past data on physical and chemical quality parameters. Statistical t-test analyses were then conducted on the observed values and past data to determine significant differences that might have occurred over the years.

Results showed that *Microcystis aeruginosa* consistently dominated the impoundment at bloom levels during summer months. Other algal species such as *Pseudanabaena* and *Oscillatoria* spp. often associated with the *Microcystis* colonies and the planktonic diatom *Melosira granulata* var. *angustissima* were also observed. These species were more abundant in water samples than in the sediment samples throughout the season due to the favourable physical conditions such as temperature and light penetration required for photosynthesis in the upper water surface. However, 4 times more *Microcystis aeruginosa* colonies were identified in the sediment samples during the winter months than in late summer of 2003. This could be due to over-wintering behaviour. More so, unlike in the previous years (1980s and 1990s), *Microcystis aeruginosa* never disappeared in winter months from the water column for three consecutive years of study after the turnover of the Dam.

The average levels of basic water parameters have remained fairly the same except significant changes in the levels of sulphate (1 096 µg/L), pH (8.35) and dissolved nitrates as NO_3-NO_2 (51.94 µg/L) for this study and 1 680 µg/L, 8.56 and 71.25 µg/L for previous studies respectively. However, values obtained in this study for the period of 2003 and 2004, also revealed increased Kjeldahl nitrogen (1961 µg/L) and total phosphorus, PO_4-TOT (73 µg/L) in 2003 compared to 1 155 µg/L and 48 µg/L in 2004 respectively. The surface water temperatures were also higher in 2003. Minimum temperatures increased from 9 to 13°C and maximum from 24 to 27°C for winter and summer periods respectively.

The study concluded that changes in phosphate, nitrate and temperature during the year 2003 provided favourable environmental factors for the cyanobacterial bloom observed in the dam. These could explain the reasons for 2003 and early 2004 unacceptable high bloom season in the Dam.

This triggers an immediate warning sign based on risk assessment and allows relevant information to be processed to the stakeholders timeously. At the same time, it prepares the relevant authorities' task with both preventative and treatment options to begin preparing early enough to combat massive blooms and public protest that this Dam has attracted over the decades.

Cost: R630 000 (KSA1)
Term: 2002-2005

PCR-based marker for identification of toxic cyanobacteria strains
University of Pretoria
No 1502

Toxic cyanobacteria found in eutrophic, municipal and residential water supplies produce lethal toxins, and domestic and wild animal deaths are caused by drinking water contaminated by these toxins. Among the species causing death of livestock, blooms of *Microcystis aeruginosa* are the most common in South Africa. More than 65 microcystins have been isolated to date and they are the most abundant cyanobacterial toxins.

Monitoring the quality of water destined to public supply includes identification of potentially toxic cyanobacteria and their population density. Existing diagnostic technology does not provide for ease of analysis, since it is either specific but laborious and need specialized expensive equipment (i.e., mouse bioassays, HPLC, MALDI-TOFF) or non-specific and reasonably priced (i.e., ELISA and PPI2A assays).
The objectives of the study were to:

- Determine the genetic diversity and population structure in selected South African water reservoirs
- Determine the potential of using the *mcyB* gene sequence as a diagnostic tool in raw water to detect the presence of toxin-producing cyanobacterial spp. in South African water reservoirs.

To elucidate the genetic diversity of geographically unrelated *M. aeruginosa* strains, we applied amplified fragment length polymorphisms as fingerprinting tool, as it has previously been shown to be efficient to discern between organisms on intra- and interspecies level. AFLP fragments have been used to unravel cryptic genetic variation for a wide range of taxa, which have previously been impossible to resolve with morphological characters. A combination of primers with 2 and 3 selective nucleotides on 23 *Microcystis aeruginosa* and outgroup axenic strains was used for this purpose.

To achieve the second objective, 2 main strategies were followed. Firstly, the use of insertions and deletions (indels) present in the *mcyB* gene sequence as a fingerprint was tested, i.e. diagnostic tool to recognise the presence of 'known' toxic strains in water reservoirs. And secondly, the use of nucleotide polymorphisms present in the *mcyB* gene sequence, with putative function in toxin production for association genetics and as a diagnostic tool was investigated.

The usefulness of AFLP that is based on the selective amplification of genomic restriction fragments by PCR was investigated to differentiate between geographically unrelated *Microcystis* strains. In total 23 strains were subjected to the AFLP fingerprinting. After analysis of the data on the basis of the average linkage method, known as the Unweighted Pair Group Method using Arithmetic averages (UPGMA), a dendrogram with four clusters was obtained.

The study provided evidence for the applicability of AFLP in cyanobacterial taxonomy, and furthermore clearly demonstrates the superior discriminative power of AFLP towards the differentiation of geographical unrelated *Microcystis aeruginosa* strains that belong to the same species.

The recent identification of the *mcy* genes in the production of microcystin synthetase for the first time provides an avenue to study microcystin production at a genetic level. This study used PCR based technologies (i.e., PCR and quantitative real-time PCR), ELISA and PP2A methods for detection of strains present and determination of their toxigenicity. The presence of the toxic cyanobacterial strains was confirmed through the use of molecular markers that detect the presence of some of the *mcy* genes in the *mcy* gene cluster that is able to synthesize microcystin toxins in *Microcystis* spp.

In the study it was shown that the population structure of *M. aeruginosa* strains from South Africa proved to be very diverse, and different from strains from other geographic regions (i.e. North America, Europe and Asia). It has also been found that polymerase chain reaction (PCR)-restriction fragment length polymorphisms (RFLPs) may be a cheap alternative for species and/or strain identification, provided that an array of enzymes are used to ensure proper identification. However, the combination of PCR and quantitative real time (qRT)-PCR proved superior in terms of accuracy, time and costs. In the study, it was shown that using the *mcyB* gene in PCR assays, applied directly to environmental samples provide a useful indicator of putative toxicity, since the genetic potential of a strain to produce microcystin is measured. The PCR-based assays detect toxigenic cells rather than toxins and require little sample preparation and modest capital costs. Detection of toxic *Microcystis aeruginosa* strains through molecular markers for microcystin may have great end use-potential in routine analysis of aquatic ecosystems. Thus, it may make water monitoring more feasible and allow the early application of corrective action before cyanobacterial blooms start to decompose or disintegrate. The PCR-based assay is effective at a level of 10 cells/ml and can indicate a possible toxic bloom well before the cell count reaches the action alert at a cell density of 2 000 cells/ml (National Health and Medical Research Council/Agriculture and Resource Management Council of Australia and New Zealand 1996) and a high alert level of 20 000 cells/ml, where blooms may contain sufficient toxin to be of concern for human health.

Cost: R668 500 (KSA 1)
Term: 2004-2007

THRUST 2: DRINKING WATER

Programme 1: Drinking water quality management

Determination of the specific origin of contaminating bacteria in drinking water of rural households by elucidating the contamination pathway using amplified fragment length polymorphism (AFLP)
CSIR
No 1602

To improve access to better quality water in rural areas in South Africa much effort has gone into providing people with protected boreholes and standpipes at some distance from their homes and it is mostly stored in-house in containers. It has, however, been shown that the microbial quality of the water stored in-house, determined by indicator organisms such as faecal coliforms, deteriorates considerably between point-of-collection and point-of-use. The study was aimed at gaining information about the most likely point of introduction or origin of

enterococci bacteria into drinking water stored in rural households.

Enterococcus species were specifically selected for this study because of its ability to survive for longer periods than *E. coli* in the environment. The AFLP method was applied to determine the genetic relatedness of enterococci isolates isolated from the source waters, water from storage containers, drinking cups, hand-swab samples, some swab samples taken from the outside surface of the drinking cups, porridge, rice and dung from domestic animals. Analysis of the AFLP results obtained for the enterococci isolates obtained for the 30 households that were dependent on an untreated river water source and 5 households dependent on a less contaminated drinking water source showed a very wide variety of genetic patterns. The genetic relatedness of the enterococci isolated during this study could not directly be related to a specific genetic pattern in the domestic samples of the households, a specific place for the introduction of the contaminants or their origin. The genetic patterns, however, highlighted specific links that could be associated with handling of food and water in individual households. It would be possible to successfully apply this method for a specific, local purpose. The high genetic diversity confirmed that multiple contamination sources are involved in contamination of drinking water. The identical genetic patterns observed for a considerable number of AFLP types, associated with a specific sample type, for example the river water or the storage container waters, indicated clusters of enterococci which have undergone subtle changes in the genetic material. These changes take place once the bacteria enter and have to adapt to a new environment where they almost become a 'different' organism in order to survive. A clear pattern, showing genetic links between enterococci isolated from individual households, rather than between neighbouring households, indicated that contaminants are specific to households and their individual household practices. The findings of this study indicated that the AFLP fingerprinting method may be better suited for understanding the occurrence and spread of selected contaminating organisms in a specific localised setting.

Cost: R371 320
Term: 2005-2007

Programme 2: Water treatment technologies and reticulation systems

Enabling water fluoridation in small drinking water treatment plants
Umgeni Water
No 1530

Regulations for the fluoridation of South African potable water supplies to an optimum concentration of (and not more than) 0.7 mg/l in order to limit the development of dental cavities were published in the Government Gazette of 8 September, 2000. Water Services Providers (WSPs) had to register with the Department of Health (DoH) by 8 September 2001 for fluoridation of their water supplies to consumers – or apply for exemption. However, because of the larger safety risk foreseen for both plant operators and water users in smaller and rural water treatment plants, such plants supplying water to less than 60 000 people, currently receive, on application, temporary exemption from the Director-General: Health. This unfortunately excludes a large part of the population from receiving the benefits of fluoridation. By far the majority of water treatment plants fall within the category of supplying less than 60 000 people with potable water. In addition, most of the operators on these smaller plants are not at a skills level required by the regulations for the safe operation of a fluoride dosing facility. A need therefore existed to enable these smaller plants to administer fluoride safely through the correct choice and operation of instrumentation and equipment, as well as by innovative ways in which to make a plant fail-safe in terms of both technology and human shortcomings. The project aimed to enable fluoridation to be done safely on small water treatment plants by means of the evaluation, selection and implementation of safe handling and dosing equipment and monitoring instrumentation.

Potentially suitable handling and dosing equipment and monitoring instrumentation were evaluated at an Umgeni Water treatment plant and the following products emanated from the study and evaluation:

- A full report was produced on the various fluoridation handling, dosing and monitoring equipment evaluated, including cost implications to the water treatment plant
- A comprehensive guideline document was compiled, outlining suitable fluoridation techniques, equipment available, correct installation and use of the equipment and general safety measures that (especially) small plant personnel need to adhere to. In the light of the fact that fluoridation will go ahead in the near future, this guideline is a very timely document, which will assist especially the small water treatment facilities – but also larger plants – in ensuring that their fluoridation requirements are met in an efficient and safe way.

Cost: R1 200 000 (KSA3)
Term: 2004-2007

Improving the efficiency of disinfection in small drinking water treatment plants
University of Fort Hare
No 1531

The efficacy of drinking water treatment by small water treatment plants – and particularly the disinfection aspects thereof, is fraught with several technical and management problems. This is corroborated by the extensive documentations on the supply of water of poor microbiological quality which is unsafe for human consumption in different provinces of South Africa. In order to unravel the intricacies around the operational and management parameters impinging upon the disinfection efficiency of small water treatment plants and to ensure sustainability of potable water supply to rural communities, this study was executed, involving 181 small water treatment plants across seven provinces of South Africa. The goal was to determine the nature and full extent of the disinfection problems experienced and to provide practical and user-friendly guidelines for intervention.

From extensive surveys at these plants and their disinfection systems, it was established that equipment, maintenance, operator education, operator training, operator working conditions and management-operator interaction were normally inadequate. These aspects were quantified and graphically portrayed on the report. A detailed and user friendly guide document was further drawn up to assist in improving disinfection of final water at small water treatment plants and distribution systems. It includes practical steps and also installation and operating costs for the different disinfection systems and chemicals. This guide document is intended for use at operational and management levels by plant managers, supervisors, plant operators and plants owners, consultants and Municipal Water Local Authorities. The report and guide document will fulfil a long-standing need for more complete information on (both technical and social) aspects regarding improved final water quality produced from small water treatment systems in South Africa.

Cost: R1 000 000 (KSA3)
Term: 2004-2006

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Programme 1: Public health and hygiene awareness and education material

Health and hygiene education
Mvula Trust
No 1634

This study arose from a growing realisation that, in relation to water and sanitation infrastructure development projects, there is little consistency or coherence of approach to health and hygiene education (H&HE). As a result, many interventions are ineffectual. Further, the linkages between HIV/AIDS and the improvement of water and sanitation facilities and related H&HE are poorly addressed in this country. Accordingly, this study was established in order to clarify institutional arrangements and resources for project-based H&HE in the context of HIV/AIDS and to develop and refine for use within municipal contexts, models (covering institutional and financial arrangements) for implementing H&HE in water and sanitation projects.

An important principle that the study established is the value of keeping our institutional and financial arrangements simple, or rather to avoid complexity wherever possible. The principle that is followed is, therefore, to use existing resources and relationships, and to enhance and strengthen existing arrangements rather than to create new ones. All H&HE role-players in the sector must integrate issues relating to HIV/AIDS into their existing water and sanitation-related H&HE, and the sector needs to encourage and support this process, which is at present almost entirely absent.

The study highlights that user education and adoption of health-promoting hygiene practices should not be peripheral to infrastructure development, but should drive them. The report also makes a strong case for collaborative planning and collaboration of work efforts. It proposes the slogan 'joint planning and operational collaboration', which should be a guiding principle. It also proposes the establishment of coordinating forums at all levels, which would include the National Sanitation Task Team (NSTT) and the Provincial Sanitation Task Teams (PSTTs) but particularly at programme or district level and project level. The need for such collaborative structures for cross-sectoral, multi-group feedback and collaborative project monitoring is emphasised, and specific advocacy interventions to achieve this are recommended. Training and standards of provision receive considerable attention in the report, and it is recommended, amongst others, that accredited training should be required of most major role-players, particularly ISD practitioners. It is also recommended that some form of association or professional body be established by ISDs to monitor and identify standards of provision.

Cost: R 800 000 (KSA3)
Term: 2005 –2007

THRUST 4: SANITATION AND WASTE MANAGEMENT

Programme 1: On-site sanitation treatment technologies

Drainage in rural and peri-urban townships
Water Systems Research Group, University of the Witwatersrand
No 1440

South Africa has a backlog in water services provision. In particular, drainage of low-income urban and rural townships has been identified as a problem. The cost of full services, including stormwater and water-borne sewage is beyond the affordability of many people, yet health and well-being are important for all. The study intended to identify the problems associated with drainage of low-cost townships in peri-urban and rural settings. It evaluated flows and water quality of sewage, grey water and stormwater in Alexandra Township, Kliptown, Madadeni and Kwamathukuza, an informal village in KZN without services. Stormwater has the greatest potential for picking up pollutants and transporting them to waterways resulting in pollution of potential water sources. That is because liquid streams, i.e. sewage and waste are usually well defined even if informal and it is a relatively simple matter to install drainage, whether it be surface channels or sub-surface pipes.

The study has found that solutions can be 'on site', or 'end of pipe'. Disposal on site is not possible in dense urban areas, but can be done in low-density (rural) environments. The volume and quality are of concern in dense settlements, but transportation and treatment is the problem in rural areas. Whereas sewage and greywater can raise health hazards if not disposed of correctly, stormwater also poses physical danger. Increased runoff is accentuated by denser buildings, which obstructs waterways. Flooding and property damage become worse due to rising flood levels and inability to evacuate. Blockage of storm drains by litter makes overflow worse. Structural end-of-pipe techniques are employed to treat residual effluent that cannot be cost-effectively controlled at source. Ranges of end-of-pipe control are available which aim to improve urban runoff. It is unlikely that there will be a single universal solution to all of the stormwater management issues. Hence an integrated suite of non-structural and structural management techniques will generally be required. This approach can achieve a balanced environmental and cost-effective outcome. The greywater samples from Alexandra, Klipspruit and Newcastle indicated that on-site, collective treatment of greywater and stormwater is possible, but sewage should be treated off site in dense settlements, whilst in low density rural settlements it can be treated in pits. Greywater can be led away in low-cost drains where necessary.

If water drainage is to be provided for all urban and rural residents, alternative solutions must be sought. Conventional separate sewers and storm drains are relatively expensive. The cheapest alternative is often grey water drainage, with onsite sewage disposal and surface stormwater discharge. But hygienic sanitation demands water-borne sewerage or new approaches to black water disposal.

Cost: R520 000 (KSA 3)
Term: 2003 – 2005

Programme 2: Use of waste as a resource

Adopting internationally acceptable methods and building capacity to measure helminth ova in wastewater and sludge samples
Zitholele Consulting (Pty) Ltd
No 1662

The objective of this study was to adopt and document an internationally acceptable method to measure helminth ova in wastewater, sludge and soil samples, and subsequently build capacity in South African Water and Wastewater Laboratories on the method. The motivation for the project is that in South Africa, currently no standard method exists for measuring helminth ova in wastewater, wastewater sludge or soil samples. The presence of *Ascaris lumbricoides* eggs is frequently the only 'standard' that is used. This project thus sought to evaluate the strengths and cost-effectiveness of two methods

- An adapted EPA method as recommended by Professor B. Jiménez's Research Group, at the Institute of Engineering, National Autonomous University of Mexico
- The ammonium bicarbonate/zinc sulphate – AmBic/ZnSO4 method developed and reported by the Pollution Research Group in South Africa.

Both these methods were evaluated for suitability, efficiency and cost- effectiveness. The adapted EPA method, the Visser® Filter method (a commonly used method) and the PRG's AmBic/ZnSO4 method, for the extraction of helminth ova from human waste materials, were tested in collaboration between the Mexican group, the UKZN-PR Group and ERWAT. This work resulted in a simpler, cost-effective and accurate method for the South African context. The method, which is based on a combination of washes, filtrations and flotations, has been adapted into three 'separate' methods to suit the main groups of waste products, viz. wastewater or effluent, wet sludge, and dry or composted sludge and UD-waste.

As part of this study, seven laboratories were trained on the method at two training sessions that were held during February 2007. This report documents the procedure and approach followed, the final methods, the training sessions and feedback received.

Cost: R273 000 (KSA3)
Term: 2006-2007

CURRENT

THRUST 1: RESOURCE PROTECTION

Programme 1: Detection, prevention and management of water related microbial agents

The effects of streamflow manipulation on the intermediate hosts and vector populations of disease and the transmission of associated parasites
Institute for Natural Resources
No 1589

Altering the flow of a water body will alter the environment. One of the effects of an altered environment is a change of the organisms that inhabit the environment. When making decisions on environmental flows, the status of disease vectors or intermediate hosts is not considered, and yet diseases such as malaria, bilharzia (in people) and fascioliasis (in livestock) have a substantial impact on the economy of areas where they prevail. The overall objective of this study is to assess the impact on the economy and to investigate ways in which it can be ameliorated, either through management actions or through altering the behaviour of the population groups at risk.

Estimated cost: R400 000 (KSA2)
Expected term: 2006-2009

The environmental exposure and health risk assessment in an area where ongoing DDT spraying occurs
University of Pretoria
No 1674

The presence of DDT and metabolites in single pilot water, sediment and fish samples from the Vhembe district, Thohoyandou, Limpopo Province, is of concern. The concordantly high prevalence of urogenital birth defects and the DDE concentrations in cord blood in babies born in a DDT-sprayed area should be regarded as a matter of extreme concern. The research question is whether environmental levels of DDT and DDE may contribute to adverse health effects in catfish and may pose a health risk for humans. The project will review the effects of EDCs on aquatic invertebrates and develop a comprehensive research programme to investigate the use of aquatic invertebrates as monitors of ecological health effects of endocrine disruptors. A further objective is to link possible health effects in biota from a DDT-sprayed area to adverse health effects in humans living in the Vhembe area. A scenario-based health risk analysis will be performed, EDC assessment techniques evaluated and a toolkit of tests for wider application in other spraying areas will be developed.

Estimated cost: R1 985 000 (KSA2)
Expected term: 2006-2010

Determine the applicability of Ecological Informatics Modelling Approaches for South African conditions with preliminary testing on the occurrence of algal blooms in eutrophic impoundments
University of the North West
1675

Algal blooms are not only nuisance-causing in water bodies, but are able to, under certain circumstances, form toxins which affect both humans and animals – with specific reference to hepato-toxicity. The project will research methods to predict algal blooms and the application of these tools; collect and collate an extensive dataset of five eutrophic impoundments in South Africa containing climatological data, physical and chemical data; adapt the deterministic SALMO model for application as an algal bloom prediction tool for use by local water resource managers and potable water treatment works; apply ecological informatics in the field of algal bloom prediction; and organise an Ecological Informatics Workshop to make known the cyanobacterial toxin prediction tool and to expand South African knowledge on the application of artificial neural network modelling and evolutionary algorithm approaches in ecosystem research.

Estimated cost: R225 000 (KSA2)
Expected term: 2006-2008

Thyroid-disrupting activity in South African waters: Amphibian metamorphosis as biological model to study effects of endocrine contaminants on thyroid function
University of Stellenbosch, Department of Zoology
No 1680

Endocrine disruption of the control and functioning of the reproductive system is of global concern but there is also evidence that EDCs may interfere with the normal functioning of the thyroid system. Changes in thyroid function could adversely affect several physiological systems in humans and wildlife but the specific effects and toxicants involved is not well-known. This project aims to set-up, validate and review protocols of the *Xenopus* metamorphosis assay (XEMA) for testing effects of waterborne chemicals on the Thyroid endocrine system. A chemical and water serial diluter system and a flow-through water exposure system for EDC screening will be designed and tested.

Estimated cost: R400 000 (KSA2)
Expected term: 2006-2007

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface and groundwater
University of Pretoria
No 1686

The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Approximately 75% of all bovine wastes produced in SA stem from the feedlot production system. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. In SA no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal.

In this study the presence/absence of veterinary drugs in the effluent of a number of feedlots will be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources close to identified feedlots screened for estrogenic and anti-androgenic activity. A reproductive toxicology study will further be executed, *inter alia* on the sharptooth catfish.

Estimated cost: R1 900 000 (KSA1)
Expected term: 2006-2009

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

Application of the CHEMPROP Model for South African conditions to predict the environmental fate of toxic organic chemicals in the aquatic environment (as a contribution to the National Toxicant Monitoring Programme (NTMP)
Rand Water
No 1475

The software CHEMPROP was developed in Germany and facilitates the prediction of physiochemical properties and associated environmental fate of organic compounds, as well as the baseline toxicity to aquatic organisms and is based on the structural composition of compounds. It was designed as a research tool for developers and experts. It will be tailored as a specific prediction tool for the local conditions that could be used to govern the selection and optimization of subsequent analytical procedures.

The aims of this project are to:

- Develop and evaluate a specific fate prediction tool that is tailored for the local geographical conditions in South Africa
- Train students in the application of CHEMPROP and ensure that this technology is transferred to South Africa
- Use CHEMPROP to assist in determining sampling strategies and frequencies for the NTMP.

Estimated cost: R254 820 (KSA 1)
Expected term: 2004-2006

New detection methods for EDCs
University of Stellenbosch
No 1534

The project will aim to produce and test an endocrine disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand binding domain (LBDER) into a suitable yeast (*Pichia pastorus*) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotynilation of LBDER and preparation of biotynilated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialized polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection.

Estimated cost: R647 500
Expected term: 2004-2007

An investigation into the occurrence of endocrine disrupting chemicals, organochlorine pesticides and heavy metals (Cd, Zn, Ca and Pb) in surface waters of the Northern Province
University of Venda
No 1557

Organochlorine pesticides (OCPs) and heavy metals have been implicated in endocrine disrupting activities. In studies done in the Northern Province DDT was detected in the streams and rivers, thus pointing to pesticide pollution of water sources. It is important to widen the scope of the studies done to get a clearer picture of the pollution profile of the source waters that could be detrimental to human, animal and ecosystem health.

Estimated cost: R60 000
Expected term: 2004-2007

Persistent organic pollutants (POPs) in the water environment
North West University
No 1561

Although the WRC has recently funded work on POPs in the water environment, this research will now be taken further in order to:

- Better identify and quantify the fate and effect of selected POPs in the hydrological cycle
- Assess with higher confidence the scale and significance of the occurrence of POPs in the environment in South Africa, and the potential short-term and long-term impacts on water resources and water-linked ecosystems
- Support the development of appropriate policy and regulatory measures to ensure implementation of the requirements of the Stockholm Convention.

Estimated cost: R1 500 000 (KSA1)
Expected term: 2005-2008

Osmoregulation in freshwater invertebrates in response to exposure to salt solution
Rhodes University
No 1585

The project aims to undertake acute and chronic toxicity tests using selected salts and indigenous macro-invertebrates as well as oxygen consumption and osmolarity tests to evaluate the salt boundary values for application in environmental water quality in setting resource quality objectives.

Estimated cost: R209 000 (KSA2)
Expected term: 2005-2007

Programme 3: Management of eutrophication and algal toxins

Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers
Rand Water
No 1445

An increase in the eutrophication of surface water resources is leading to an increased incidence of toxic blue-green algae growth – thereby increasing health risks for drinking water from a treatment plant which does not use activated carbon adsorption in its process train. No structured framework exists yet in South Africa to manage the supply of safe drinking water during a persistent blue-green algae bloom in source water. This project aims to establish a pro-active approach by means of a generic algal bloom incident management framework to effectively manage potable water supplies when toxic algal blooms are present. Such a system will be widely applicable to water service providers and will reduce the risk of human health-related incidents related to blue-green toxins by providing this framework for informed and appropriate pro-active management measures.

Estimated cost: R236 000 (KSA3)
Expected term: 2003-2004

Methods manual for monitoring phytoplankton and cyanobacteria
Rand Water
No 1533

There is no uniformity in the manner in which water suppliers approach the monitoring of phytoplankton and algal blooms, with the result that incompatibility of data makes it difficult to draw conclusions regarding the extent of the problem. The aims of the proposed project are to:

- Synthesise current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis and geosmin and MIB analysis nationally and internationally
- Compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins and geosmin and MIB for South African freshwaters
- Compile a summarised reference document.

Estimated cost: R403 600 (KSA 3)
Expected term: 2004-2006

Programme 4: Management of impacts of land use activities on surface and groundwater at a catchment level

Modelling non-point source pollution in agriculture from field to catchment scale
Sigma Beta Consulting
No 1516

It is increasingly recognised that non-point source, or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. This further results in a negative impact on plant, animal and human health. The project will address those issues that require priority attention, with regard to non-point source pollution.

Estimated cost: R5 000 000
Expected term: 2004-2009

THRUST 2: DRINKING WATER

Programme 1: Drinking water quality management

Compilation of a generic water safety plan for small community water supply
Umgeni Water
No K8/649

The objective of this project is to develop a model water safety plan for South Africa that will consider water supply from the catchment to the consumer, including treatment processes and piped distribution systems. The model water safety plan will incorporate existing systems as well as new systems and will yield a comprehensive checklist and guidance manual for the evaluation of water supply. The model plan will mainly be aimed at small and rural water supply, but will also be usable by larger suppliers. This project ties in with the WRC's rural water management activities in conjunction with the WHO.

Estimated cost: R196 000 (KSA3)
Expected term: 2006-2007

Compliance of non-metropolitan South African potable water providers with accepted drinking water quality and management guidelines and norms
University of Fort Hare
No 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other, operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers which are preventing compliance to these guidelines and norms, and communicate these solutions to the Municipal Management. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000 (KSA3)
Expected term: 2006-2007

Programme 2: Water treatment technologies and reticulation systems

Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof
Emanti Management
No 1597

Small water service providers are having problems in proactively managing drinking water quality within their distribution networks. This project aims to analyse the relatively high percentage of water quality failure in two provinces of South Africa and in particular contrast the water quality at the water treatment plant with that at point of use. Guidelines will then be developed for the management of drinking-water quality in non-metropolitan distribution systems. The guidelines will include legislative compliance requirements, technical inputs (e.g. optimum free chlorine residual levels), best practices (e.g. pro-active maintenance requirements), monitoring and management protocols and reporting protocols to consumers, provincial and national government. These guidelines will then be used in a 'road show' to make the appropriate officials aware of the need for effective monitoring and management.

Estimated cost: R452 300
Expected term: 2005-2007

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Programme 1: Public health and hygiene awareness and education material

Involving traditional healers and myths and stories in hand-washing/hygiene education/sanitation promotion initiatives
Sigodi Marah Martin
No 1521

This study will examine the myths and traditional practices around WSS and hygiene, with the intention of developing strategies to involve traditional healers and the practices in promotion of health and hygiene activities and messages. The project offers a fresh approach at using local resources and systems to promote good sanitation and hygiene.

Estimated cost: R326 000
Expected term: 2004-2006

Programme: Development of Health-Related Guidelines: Vol. 5 What We and Our Children Need to Know – Health and Hygiene Awareness
University of Venda
No 1672

This is the last guide in the series and will address the management of water-related microbial diseases in the household. The guide will be developed by women for women.

The aims of this document will be to provide basic information on the causes of diseases and the pathways of infection to provide an understanding of the management of such diseases at household level.

Estimated cost: R200 000 (KSA3)
Expected term: 2006

Programme 2: Capacity building and training programmes for public health professionals and practitioners

A Guideline Document for the Implementation of Sanitation, Health and Hygiene Education Programmes in Informal Settlements
Nemai Consulting
No 1656

The provision of a guideline/tool for promotion of HHE in informal areas is a gap identified by current research. Where environmental health workers are appointed, their services are usually not directed at sanitation-related health & hygiene promotion. Very few WSAs have a sanitation department/unit that deals with low-cost sanitation. Where such sanitation departments/units exist, and there are sanitation managers, a limited number of these managers understand the specific requirements posed by alternative sanitation delivery. This study is a small step in assisting water services to engage with informal areas in the promotion of HHE and sanitation. The tool is aimed at empowering them on how to address the situation and provide a sustainable service. The current typhoid outbreak is a good example of the lack of education in informal areas, alleviated by poor management of water and sanitation services.

Estimated cost: R570 000 (KSA3)
Expected term: 2006-2008

Programme 3: HIV/AIDS linkage with water quality and quantity and access to adequate sanitation service

Molecular relatedness of enteric pathogens isolated from water sources and HIV/AIDS patients with diarrhoea in rural communities in the Limpopo and Eastern Cape Provinces
University of Venda
No 1633

The project aims to isolate and characterise bacterial enteropathogens from water sources and from HIV/AIDS patients with diarrhoea and controls in rural communities in the Limpopo Province. It will also establish any epidemiologic linkage between bacterial enteropathogens from water sources and those from HIV/AIDS patients with diarrhoea in rural communities in the Limpopo Province. The antimicrobial susceptibility profiles of enteric isolates from water sources in comparison with diarrhoeagenic pathogens from HIV/AIDS patients will further be determined in order to guide clinicians on the empiric treatment of diarrhoea cases requiring antibiotic therapy in HIV/AIDS patients.

Estimated cost: R900 000 (KSA3)
Expected term: 2005-2008

Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS
University of Venda
No 1653

The lack of safe water compounds health risks to HIV/AIDS individuals leading to increased vulnerability, decline in productivity and income and consequently a general decline in their socio-economic status. HIV/AIDS is not a water-borne disease therefore there appears to be little relation to each other but a poor microbiologically quality of their drinking water could have detrimental impacts on the health of HIV/AIDS infected individuals. This project aims to do a health impact assessment study based on the microbiologically quality of drinking water used by rural households that have at least one HIV/AIDS infected individual. The presence of selected pathogenic and opportunistic bacteria and viruses in drinking water with those present in stool samples of both people living with HIV/AIDS and healthy individuals will be correlated to identify the relationship between point-of use drinking water quality and health indicators (such as diarrhoeal morbidity and mortality).

Estimated cost: R800 300 (KSA3)
Expected term: 2006-2008

THRUST 4: SANITATION AND WASTE MANAGEMENT

Programme 1: On-site sanitation treatment technologies

Strategy for the furtherance of knowledge and good practice of ecological sanitation (Ecosan) technology in South Africa
Boutek, CSIR
No 1439

VIP toilets, correctly engineered and implemented, are a good means of providing a dry sanitation service, but these systems are not without their problems. If a dry toilet (i.e. not requiring water for its operation) is designed and constructed in such a way that the faeces vault can be quickly, easily and safely emptied, then one of the biggest maintenance problems will be obviated. If the processed excreta can also be productively and safely used for agriculture, the technology will become even more attractive. In South Africa, where many rural communities rely on subsistence agriculture, often in poor soils, and with urban agriculture becoming more common, this is an important aspect. Urine-diversion ecological sanitation (Ecosan) systems address the above problems. They have been successfully implemented in many countries, including South Africa where about 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. A need has thus been identified to create further competence in this area of sanitation in South Africa, and to increase knowledge concerning the technology. This study aims to develop strategies and guidelines, through monitoring and evaluating existing schemes, which would provide fundamental answers in the sustainable management of this technology.

Estimated cost: R820 000 (KSA 3)
Expected term: 2003-2006

Understanding the disposal and use of grey-water in the non-sewered areas in South Africa
University of Cape Town
No 1524

There is a strong drive from the South African government to attain basic water and sanitation coverage. The level of service to meet this requirement being applied by the majority of authorities in urban and rural areas relate in most cases to on-site dry latrines (VIPs or equivalent) and 25 ℓ/cap· d of drinking water. As water and sanitation services are attained and improved, the potential for problems related to the disposal and management of grey-water will emerge. Solutions are required to circumvent or minimise these problems. The study aims to undertake a complete scoping exercise to identify current and historic grey-water management initiatives in urban and rural areas, and to identify problem areas/challenges. Determine and assess existing management and disposal practices within South Africa.

Estimated cost: R800 000 (KSA 3)
Expected term: 2004-2006

Research into urine diversion toilets in eThekwini
University of KwaZulu-Natal
No 1629

The study aims to provide a scientific basis for the design and operation of urine diversion (UD) toilets, evaluate their effectiveness and determine the fate of Ascaris eggs in the toilets. The study puts forward a problem that is emerging around service delivery issues related to the use of urine diversion toilets. eThekweni has taken on the championing of the technology and has modified its design. Success of etheweni's initiative will be of relevance to the rest of the country in the use of the technology. This research is a direct outcome of a strategy workshop hosted by eThekweni and WRC. The fate of pathogens in UD toilets is not clear, that is what happens to pathogens in a dehydration process that is the basis of the operation of UD systems. This lack of understanding is an inhibitory factor in the use of pit contents, as well safe handling of faecal sludge. Thus, the management and operation of the UD provide greater challenges than just the sanitation convenience. The study intends to find answers to these challenges which would make the option of UD more acceptable and improve the management aspects.

Estimated cost: R600 000
Expected term: 2005-2007

Scientific support for the design and operation of ventilated improved pit-latrines (VIPs)
University of KwaZulu-Natal
No 1630

The project aims to investigate and determine the fate of different pit-latrine additives and their performance, using newly developed testing procedures in wastewater treatment. The project is very important in light of previous attempts by the WRC to evaluate pit additives that did not live up to promise. The sector is continuously in demand for this information.

Estimated cost: R600 000
Expected term: 2005-2007

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Programme 1: Impacts of quality of irrigation water on human health

Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams
Division of Aquaculture, University of Stellenbosch
No 1461

Most irrigation areas make use of on-farm storage dams to store water until it is required for the irrigation of crops. The existence of these dams presents an opportunity to utilise them also for fish production. Benefits associated with this dual use of farm dams include the additional income associated with such an enterprise, the supply of fresh fish as protein source for local communities, the creation of additional employment opportunities and a potential reduction in fertiliser requirements for crop production, as a result of the enrichment of the irrigation water by fish food and excrement. Although dual use is practiced in many countries, it is not common in South Africa. In the light of the potential benefits associated with the integration of aquaculture production with irrigation practice, it is proposed that the interaction between these two practices, the benefits and disadvantages associated with such integration and ways to maximise the benefits, be investigated for two case studies. Specific attention will be given to water quality effects and the precautionary measures that are required in order to maintain fitness-for-use.

Estimated cost: R1 000 000
Estimated term: 2003-2007

Development of a strategic research programme for toxic algal blooms
Targeted consultancy
No K8/576/7

There are various possible products on the market that could potentially be used to control toxic algae blooms. The aims of this consultancy will be to conduct a literature study on existing and possibly available methods and develop a ToR of a research programme, for using these methods in SA conditions to evaluate their performance under field conditions; and determine the economic viability and commercialisation of the product(s).

Estimated cost: R200 000
(Impact area-WATER and HEALTH)
Expected term: 2004-2006

NEW

THRUST 1: RESOURCE PROTECTION

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

Scoping study to investigate the possible pollution of endocrine disrupting compounds (EDCs) from agricultural activities in South African water systems
Private Consultant: Mrs AEC Burger
No 1774

In crop production and animal husbandry a number of chemicals are used that have an influence on the endocrine systems of humans and animals (EDCs). The intake of these chemicals may lead to a variety of problems in the reproductive- neurological-, immunological systems as well as thyroid function in humans and animals. Very little is known about the occurrence, magnitude and influence of these chemicals in South African water systems and food products. In agricultural practices chemicals are mostly used for pest control and fertilisation of crops and for pest control, disease (parasite control) as well as growth promoters in animal husbandry. Not all chemicals used in agriculture have EDC properties. In this project a framework will be developed to determine the influence of agricultural chemicals with EDC activity in water systems and the following steps will be taken:

- A survey will be done on the type of crop cultivated. Each crop has its own set of chemicals registered for use
- Determine whether farmers are using only registered chemicals or all 'available' chemicals
- Determine the chemicals used for the crops (based on questionnaires addressed to farmers, co-operatives, local merchants, etc.)
- Select the chemicals with EDC properties with literature survey on their persistence in the environment
- Collect data on the volumes used and frequency of application, practices on mixing of chemicals on the field, and disposal
- Study of the geological make-up of the area to determine whether chemicals may reach rivers or dams. Information regarding the geological make-up of the areas will be obtained from the available geological survey.

The main outputs will be reports on crop production and animal husbandry in selected catchment areas; agricultural chemicals used in these catchment areas; level of pollution of water systems in the catchment areas and the probability of agricultural chemicals with EDC properties entering the water system.

Estimated cost: R250 000
Expected term: 2007-2008

Programme 3: Management of eutrophication and algal toxins

Investigation of the distribution and diversity of South African toxic freshwater cyanobacteria with special reference to analysis of the neurotoxin BMAA and molecular genetic methods for microcystin screening
NMMU
No 1719

There exists a lack of standardised methods and facilities for analysis of toxic cyanobacteria and quantification of cyanobacterial toxins in South Africa. Commercial primer sets for such screening will soon be available, but their suitability or applicability to South African isolates is totally unknown. No comprehensive analysis of wild strains has been attempted using any molecular technique. The application of appropriate techniques will yield information on the relationship between South African and other strains and information on the distribution and spread of strains within South Africa. Screening studies by various laboratories have indicated that all known species of cyanobacteria can produce BMAA. This has obvious implications for the human/health-related chronic exposure to BMAA in water where cyanobacterial aggressions occur.

The aim of the study will therefore be to investigate the distribution and diversity of South African freshwater toxic cyanobacteria from a phylogenetic/phylogeographic perspective with specific reference to toxigenicity for known toxins and including the establishment of analytical procedures for the novel toxin BMAA.

Estimated cost: R1 000 000 (KSA 3)
Expected term: 2007-2009

THRUST 2: DRINKING WATER

Programme 1: Drinking water quality management

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water
CSIR
No 1749

The Department of Water Affairs and Forestry is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles where used in the 1996 *South African Water Quality Guidelines* (**Vol 6**: *Aquatic Environment*), the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in

characterising the biotic effect of various endocrinal active substances at various levels of biological organisation, critical interpretational gaps remain. In its commonly used paradigm, health risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water.

The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500 (KSA 1)
Expected term: 2007-2009

Investigation into the effects of water quality (organic vs. inorganic) on the immune systems of humans
University of the Western Cape
No 1756

This will be a comprehensive study on the effects that water quality may have on the immune system of humans. The quality of potable and raw water could vary considerably from place to place and this depends on the microbiological and chemical constituents of the water. Several of the physiological systems (e.g. immune, thyroid-hypothalamus, reproductive and the neuro-physiological system) can be impacted on by the quality of the water. The complexity of mixtures is that different constituents (depending on the concentration of each) could have synergistic or antagonistic or no effects in the particular mixture on the human body. Some man-made chemicals affect the function of one or more immune pathways and this can have adverse effects on the health of man and animals. The objective of the study will be to develop and validate analytical tools to evaluate the impact of aquatic pollutants on the immune system.

Water extracts obtained from various areas will be evaluated for its immunotoxicity. Analytical procedures will be verified to measure the different effects on the human immune system.

Estimated cost: R1 500 000 (KSA 1)
Expected term: 2007-2010

Situation and gap analysis of water quality testing in South Africa
Jeffares & Green
No 1720

The irregularities and occasional health risks currently experienced in water quality throughout South Africa highlights the urgent need for the introduction of an accepted and practical water quality testing standard, to be employed by all laboratories in South Africa and enforced at national regulatory level. In order to produce such a standard, a thorough investigation should be carried out into existing conditions, problems and capacities of all water testing laboratories in South Africa. The assessment of the current status of testing laboratories will play an important role in establishing what action needs to be taken to ensure acceptable water quality throughout South Africa.

The overall aim of the project is to develop a strategy for a national programme that will address the needs of water quality assessment in South Africa by conducting an audit of the status and capacity of all available water laboratories considered to be capable of conducting chemical, microbiological, toxicity and bio-assays on water and wastewater samples.

Estimated cost: R800 000 (KSA 3)
Expected term: 2007-2009

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Programme 1: Public health and hygiene awareness and education material

A Guideline Document for Emergency Disinfection of Drinking Water
Tshwane Institute of Technology
No 1737

Untreated or inadequately treated water is still drawn directly from rivers, ponds, streams, and boreholes in some South African rural communities for domestic use. Various water-related infectious diseases, including diarrhoea are often contracted and in some cases causing the death of the immuno-compromised individuals. In some instances, following natural disasters a local authority may urge consumers at risk of contracting water-borne diseases to follow emergency disinfection measures. Messages and recommendations regarding the 'emergency' disinfection of untreated water do not take into account the variation in the quality of the source water. General guidance and recommendations on the use of a disinfectant or boiling of the water are usually given. In some instances, this could add to the detrimental health effects of the water. The aim of this study is to consolidate available literature and information and to develop a user friendly guideline for emergency disinfection of untreated water.

Estimated cost: R600 000 (KSA 3)
Expected term: 2007-2009

Programme 3: HIV/AIDS linkage with water quality and quantity and access to adequate sanitation service

Assessment of water, sanitation and hygiene services in relation to home/community based care services for HIV/AIDS infected individuals in rural and peri-urban areas of South Africa
University of Venda
No 1738

This project will be done in collaboration with the Department of Health and will provide an extension of the project funded by DoH. The HIV/AIDS epidemic has a devastating effect on the health and well-being of the South African nation, but it also holds grave consequences for the socio-economic development of South Africa. Safe water and sanitation are basic needs and a human right, especially for people affected by HIV/AIDS as it will help them to live longer in good health and maintain their dignity. This project will highlight the issues underlying the broad context for water supply, sanitation, and hygiene behaviour, and the need for systematic attention to these. This will be done in collaboration with DoH and the MRC.

The aim of this study is to provide insight into the extent to which water, sanitation and hygiene issues/practices are important and relevant for service providers and people living with HIV/AIDS, especially with regard to home/community-based care.

Estimated cost: R500 000 (KSA 3)
Expected term: 2007-2009

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Programme 1: Impacts of quality of irrigation water on human health

A quantitative investigation into the link between irrigation water quality and food safety
University of Stellenbosch, Department of Food Science
No 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such, the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in e.g. informal settlements and failing water treatment in e.g. non-operating

sewage works. This water is often used for irrigation and there is a direct relationship between irrigation water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers. A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and internationally. The problem of contamination of irrigation water and food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets.

This research project will evaluate the extent of the problem, regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two, and provide recommendations on the way forward in terms of treatment of irrigation water.

Estimated cost: R3 300 000 (KSA 4)
Expected term: 2007-2012

THRUST 6: GOVERNANCE SYSTEMS FOR SAFEGUARDING HUMAN HEALTH

Programme 2: Regulatory framework for an integrated water quality management approach

Development of a conceptual framework for the regulation of water quality within the context of an integrated, preventative management approach
Golder Associates Africa (Pty) Ltd
No 1769

The implementation of the integrated preventive management approach that guides the *DWAF Drinking Water Quality Management Framework for South Africa* (2005) and *WHO Water Quality Guidelines* (2004) requires a well co-ordinated regulatory system for the management of the entire water supply system from the catchment to the consumer and the quality of effluents discharged into the water resources. Currently, the linkages between water resources management and drinking water quality management are not strongly followed nor addressed within the regulatory framework.

Therefore, the project aims to develop a conceptual framework for integrating the regulation of the quality of water resources with that of drinking water quality in order to support the implementation of the integrated, preventive management approach.

Estimated cost: R600 000 (KSA 1)
Expected term: 2007-2009

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CATALOGUE OF AVAILABLE TT REPORTS

KSA 1:

Fire management in the Cape Peninsula: lessons for catchment management agencies from the Ukuvuka Campaign
Fowkes SM

The Ukuvuka initiative was a short term collaborative campaign designed to inject finance, skills, innovation and passion to address a core issue of common concern to the partners - changing fire-related behaviour. Ukuvuka ran from 2000 to 2004 and was supported by the three spheres of government, business (a short-term insurance company, a bank, an oil company and a daily newspaper) and NGOs. The trigger for the initiative was the immediate crisis of fires in the mountains of Cape Town's Cape Peninsula.

The purpose of this report is to make a contribution to the policy implementation challenge by sharing some practical insights and experiences from that crisis initiative. The report focuses particularly on applying the lessons to the water sector, specifically the formation of Catchment Management Agencies (CMAs.)

Report No: TT324/07
ISBN: 978 1 77005 656 5
Overseas price: $10-00 excl postage

High-yielding groundwater areas around the Nelson Mandela Bay Municipality.
Murray R; Goedhart M; Baron J

Prime groundwater development areas were identified and grouped into five hydrogeological domains. Within each of the domains specific groundwater exploration target areas were identified and prioritised. No ground-truthing was done to verify the target areas. It is likely that some of the areas may be unsuitable for groundwater development for a variety of reasons, and it is equally likely that there are a number of other areas that could be developed for large-scale groundwater supply.

The total groundwater potential for each domain was estimated using the GRA II data sets and by assuming the number of high-yielding boreholes that could be obtained in each domain. This latter approach is based largely on estimates of the number of prime drilling targets that can be located. It was not based on a remote sensing analysis and the identification and weighting of individual drilling targets. Thus in some areas there may be fewer prime drilling targets, and in other areas, more. The purpose of this exercise was to provide a first-order estimate of the groundwater potential, and thus it will not be correct, but it should serve as a good starting point. A summary of the groundwater potential of all five domains is presented:

Groundwater Exploitation Potential (normal years) = 48 Mm3/a

Groundwater Exploitation Potential (dry years) = 32 Mm3/a

Borehole yield without artificial recharge and continuous abstraction= 28 Mm3/a

Borehole yield with artificial recharge and 6-month/a abstraction= 41 Mm3/a

Existing use= 9 Mm3/a

Report No: TT 327/08
ISBN: 978 1 77005 671 8
Overseas price: $20-00excl postage

National Microbial Monitoring Programme for Groundwater: Implementation Manual
Murray K, du Preez M; Meyer R; van Wyk E; Parsons R; Flanagan L; Taylor M

The general purpose of this manual is to describe how the national microbial monitoring programme (NMMP) for groundwater should be implemented on a national scale. This national monitoring programme for groundwater supplements the National Microbial Monitoring Programme for surface waters. However, it should not be regarded as an extension of it. Monitoring groundwater is fundamentally different from monitoring surface water and accordingly has a completely different design.

This manual gives guidelines, procedures and methods for microbial monitoring of groundwater as well as how and when such data can be reported.

Accordingly, this manual is aimed at a variety of people and organisations. It is initially aimed primarily at DWAF officials who will have the primary responsibility to implement national water-related monitoring programmes. However, it is also aimed at Catchment Management Agencies (CMAs) and water management institutions to which monitoring responsibilities may be delegated.

Report No: TT 312/07
ISBN: 978 1 77005 594 0
Overseas price: $20-00 excl postage

Integrated water resource management plan guidelines for local authorities: (IWRMP)
Burke J

The principle of integrated water resource management is endorsed by the National Water Act, Act 36 of 1998 and the National Water Resource Strategy (2004). Simply put, integrated water resource management in Local Authorities is about striking the right balance between a Local Authority's developmental role and the need to maintain environmental integrity in fulfilling the Constitutional obligations of sustainable development, socioeconomic development and a safe and healthy environment. Striking this balance is a challenge and requires cooperation between all tiers of government as well as between government and the private sector, but there are no hard and fast rules as the environment is a dynamic system, continually adapting itself to a new balance, following the effects of both human and natural influences on it. Implementation of the Local Authority Integrated Water Resource Management Plan will be a positive step forward in ensuring that Local Authorities achieve sustainable integrated water resource management in line with the catchment vision set by the Catchment Management Agency

Report No: TT 304/07
ISBN: 978 1 77005 548 3
Overseas price: $30-00 excl postage

A task oriented approach to participation: PLEASE DOWNLOAD FROM http://www.wrc.org.za/
Burt JC; du Toit DR; Neves DT

The NWA puts emphasis on the decentralization of water resource management to the catchment level. This necessitates an adoption of participatory management approaches that can support a multi-stakeholder dialogue of diverse interest groups such as water user associations (WUAs), community based organisations, NGOs, water resource managers, policy-makers and planners.

Therefore, there is a need for appropriate tools that can be used to support meaningful participation of the public at different levels of decision-making. This project answers the following questions:

- What is the appropriate CMA level of organisation that will be effective in ensuring that voices of marginalized groups are also taken into consideration in the governance of CMAs?
- How can civil society be best organized to play a meaningful role in the management of water resources at a catchment and subcatchment level?

Report No: TT 289/06
ISBN: 1 77005 502 9
Overseas price: $15-00 excl postage

Water as a human right, made easy! Workbook 1: PLEASE DOWNLOAD FROM http://www.wrc.org.za/
Dericj du Toit, Teresa Sguazzin

Report No: TT 269/07
ISBN: 978 1 77005 435 6
Overseas price: $15-00 excl postage

Human Rights project WORKBOOK 2: PLEASE DOWNLOAD FROM http://www.wrc.org.za/
Dericj du Toit, Teresa Sguazzin

A key concept evident in the South African Constitution is that National Government is committed to providing adequate food and water '… to meet basic human needs'. Arguably the most crucial resource, in terms of human need, is water. This commitment in providing water for basic human needs is captured by the National Water Act (1998) in the concept of the 'Basic Human Needs Reserve' (BHNR). The notion of the BHNR essentially elevates the status of water for basic human needs to that of a human right. Although an orientation that accepts access to water as a human right is enshrined in South African law, it represents a very new concept in water management in South Africa (and the world). One of the major obstacles hampering implementation is a lack of familiarity and understanding of the notion of the BHNR by the very people tasked with the responsibility for ensuring that it is honoured, i.e. local government. An informal, preliminary survey conducted by AWARD indicates that most members of local government have not heard about the BHNR.

Report No: TT 296/07
ISBN: 978 1 77005 513 1
Overseas price: $15-00 excl postage

Guide for local government cooperation with catchment management agencies.
Mazibuko G; Pegram GC

The recent demarcation process and the on-going specification of the powers and functions between the district, local and metro councils have further clarified the roles and functions of local government. Local government is constitutionally responsible for the implementation and control of a range of activities that affect water resources. This research will amongst others provide recommendations on the requirements for co-operative governance and the most appropriate approaches and mechanisms to foster co-operative governance between CMAs and local government, to achieve a range of objectives under differing circumstances.

Report No: TT 270/06
ISBN: 1 77005 460 X
Overseas price: $15-00 excl postage

Artificial Groundwater Recharge: Wise water management for towns and cities
Rickey Murray

Report No: TT 219/03
ISBN: 1 77005 092 2
Overseas price: $15-00 excl postage

Surface water: Groundwater interaction in a South African context: A Geohydrological Perspective.
Parsons Roger

In response to a greater awareness of the role of groundwater in sustaining the environment and recognition of a unitary and interdependent hydrological system, surface-groundwater interaction has emerged as an issue requiring greater attention. This publication aims to establish the correct and consistent use of hydrological terms which is key for developing a better understanding of surface water-groundwater interaction

Report No: TT 218/03
ISBN: 1 77005 084
Overseas price: $25-00 excl postage

An explanation of a set of national groundwater, plus 2 Hydrogeological maps (SA Price: R114.00)
Vegter JR

Advances in hydrogeology over the past years, and the increasing demand on groundwater resources, have given rise to the need to portray hydrogeological information in such a manner that planners and various groundwater users can make decisions by means of a quick and accurate overview of the most up-to-date information. Hydrogeological maps are seen as a powerful tool to meet this objective.

Report No: TT 74/95
ISBN: 1 86845 183 6
Overseas price: $70-00 excl postage

Explanation of the 1:500 000 hydrogeological map 2326 Pietersburg (SA Price: R50.00)
Water Systems Management & DWAF

This is a high-quality hydrogeological map of the Pietersburg map sheet at a scale of 1:500 000 and a set of explanatory notes which provide guidelines as to the need for detailed groundwater investigations and what hydrogeological conditions are expected to occur.

Report No: TT 75/95
ISBN: 1 86845 188 7
Overseas price: $35-00 excl postage

Dealing with reservoir sedimentation (SA Price: R171.00)
Basson GR & Rooseboom A

Dam siltation has always been and still is a serious problem in South Africa. This report presents different techniques for controlling and managing dam siltation in South Africa.

Report No: TT 91/97
ISBN: 1 86845 255 7D
Overseas price: $70-00 excl postage

Sluicing flumes: A new structure for discharge measurement in sediment-laden rivers
Rossouw J, Loubser C, Rooseboom A & Bester A

This report confirms the flumes' good characteristics with respect to handling heavy sediment loads.

Report No: TT 103/98
ISBN: 1 86845 368 5
Overseas price: $35-00 excl postage

Dealing with reservoir sedimentation -Dredging (SA Price R200.00)
G R Basson A & Rooseboom

In this report the reservoir sedimentation theory and dam dredging techniques from around the world are evaluated. A criterion for selecting dredging techniques which emphasise on cost cutting measures is presented.

Report No: TT 110/99
ISBN: 1 86845 493 2
Overseas price: $60-00 excl postage

A Global Overview of Inter- Basin Water Transfer Schemes, Socio- Economic and Socio - Political Implications, and Recommendations for their Management
Snaddon CD, Davies BR & Wishart MJ

This report combines two source documents. The first is the report on the research done during the project and the second is a worldwide synthesis of information on inter-basin transfer (IBTs) with contributions from scientists in the USA and Australia.

Report No: TT 120/00
ISBN: 1 8645 583 1
Overseas price: $20-00 excl postage

Groundwater Development in South Africa and an introduction to the Hydrogeology of Groundwater Regions
Vegter J R

This report presents a historical overview from the introduction of the first drill in 1880 -a manually powered diamond rig - up to the present. The following topics are covered:

- Groundwater exploration and exploitation
- Investigation and research; and
- the evaluation of groundwater legislation

Report No: TT134/00
ISBN: 1 86845 642 0
Overseas price: $25-00 excl postage

Hydrogeology of Groundwater: Region 1 - Makoppa Dome
JR Vegter

Report No: TT135/00
ISBN: 1 86845 643 9
Overseas price: $ 20-00 excl postage

Hydrogeology of Groundwater: Region 3 – Limpopo Granulite-Gneiss belt
JR Vegter

Report No: TT136/00
ISBN: 1 86845 644 7
Overseas price: $20-00 excl postage

Hydrological information and techniques to support the determination of the water quality component of the ecological reserve for rivers
Hughes DA; Munster F

Report No: TT137/00
ISBN: 1 86845 646 3
Overseas price: $20-00 excl postage

Hydrogeology of Groundwater: Region 7 – Polokwane/Pietersburg Plateau
JR Vegter

Report No: TT 209/03
ISBN: 1 86845 027 2
Overseas price: $20-00 excl postage

Hydrogeology of Groundwater: Region 19 – Lowveld
JR Vegter

Report No: TT 208/03
ISBN: 1 86845 026 4
Overseas price: $20-00 excl postage

Estimation of streamflow reductions resulting from commercial afforestation in South Africa
Gush MB, Scott DF, Jewitt GPW, Schulze RE; Lumsden TG, Hallowes LA & Görgens AHM

The main objective of this report is to present the verification of the ACRU model on available streamflow data from experimental or research afforested catchments and thereafter to apply the model to all regions with economically viable afforestation potential.

Report No: TT 173/02
ISBN: 1 86845 845 8
Overseas price: $30-00 excl postage

A manual for cost benefit analysis in South Africa with special references to water resource development
Conningarth Economist

This document entails the guidelines in the format of a manual for conducting Cost Benefit Analysis (CBA) in South Africa with specific references to evaluating the development and management of water resources. This evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. This manual is specifically aimed at the decision maker in the public sector, but can be used outside the public sector too.

Report No: TT 177/02
ISBN: 1 86845 851 2
Overseas price: $30-00 excl postage

Hydrogeology of the main Karoo basin: Current knowledge and future research needs
AC Woodford and L Chevallier

This document is aimed primarily at the groundwater practitioners working in Karoo fractured-rock aquifers, especially those involved on rural water supply projects and WRC-funded research projects. The level of information presented is also useful to other professionals with only limited groundwater knowledge

Report No: TT 179/02
ISBN: 1 86845 851 2
Overseas price: $40-00 excl postage

Evaluation of the role of water user associations in water management in South
Pegram G; Mazibuko G

The new institutional reforms in water resource management prescribed in the National Water Act of 1998, delegate many water resource management functions (particularly resource protection and allocation) to organisations within Water Management Areas (WMA), namely Catchment Management Agencies (CMAs) and Water User Associations (WUAs). WUAs are statutory bodies intended to operate at a restricted localised level aimed at facilitating co-operative associations of individual water users, who wish to undertake water-related activities for their mutual benefit. This study is aimed at clarifying the roles of WUAs, evaluating the functioning of a number of established WUAs against this framework and the particular needs of the local conditions, and formulating guidelines for the institutional and management arrangements.

Report No: TT 204/03
ISBN: 1 8645 982 9
Overseas price: $25-00 excl postage

Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning.
Dickens C; Kotze D; Mashigo S; MacKay H; Graham M

The South African legal environment provides for the sustainable use of the country's water resources. Yet, all is not well with the wetland resources of this country. Already suffering from years of abuse and over-utilisation, wetlands remain under threat as part of the water resource. These guidelines provide management agencies with much needed information for the management of wetlands. The impact of these guidelines is expected to be significant, especially for professional staff and interested members of society working at ground level

Report No: TT 220/03
ISBN: 1 77005 096 5
Overseas price: $30-00 excl postage

An assessment of the water policy process in South Africa (1994 to 2003):
de Coning C; Sherwill T

The political changes which have taken place in South Africa during the last decade have had profound impacts on the development of new water policy, and have opened the way for significant shifts in policy and legislation generally, in relation to sustainable management of natural resources. The implementation context will strongly influence the

future development and strategic direction of water policy in South Africa, but there is still limited understanding of the inter-relationships between policy development and implementation, with the added shaping forces of politics, economics and social factors.

This project aims to provide, through critical review and analysis, an understanding of where we have come from and where we are going to in terms of water policy, in order to support ongoing development and implementation throughout this and future policy cycles.

Report No: TT 232/04
ISBN: 1 77005 180 5
Overseas price: $15-00 excl postage

Sediment control at river abstraction works in South Africa: Vol 1
Brink CJ; Basson GR; Denys F

This report presents a review of the international and South African state of the technologies available for controlling sediments at river abstraction works. Optimum abstraction locations, flushing channel designs and suitable pumping designs. Guidance for planning and design of river abstraction works is one of the main highlights of this report.

Report No: TT 259/06
ISBN: 1 77005 410 3
Overseas price: $85-00 excl postage

Considerations for the design of river abstraction works in South Africa: Vol 11
Basson GR

Report No: TT 260/06
ISBN: 1 77005 411 1
Overseas price: $40-00 excl postage

Guide for local government cooperation with catchment management agencies.
Mazibuko G; Pegram GC

The recent demarcation process and the on-going specification of the powers and functions between the district, local and metro councils have further clarified the roles and functions of local government. Local government is constitutionally responsible for the implementation and control of a range of activities that affect water resources.
This report provides recommendations on the requirements for co-operative governance and the most appropriate approaches and mechanisms to foster co-operative governance between CMAs and local government, to achieve a range of objectives under differing circumstances. The guide is a user friendly document for all levels of local government.

Report No: TT 270/06
ISBN: 1 77005 460 8
Overseas price: $15-00 excl postage

Guide for catchment management agency cooperation with local government.
This is a working guide for Catchment Management Agencies to cooperate with local governments in their areas of operation to achieve common objectives in the management of water resources and hence the development of their respective areas.

Report No: TT 271/06
ISBN: 1 77005 439 1
Overseas price: $15-00 excl postage

A synthesis of the hydrogeology of the Table Mountain Group - Formation of a research strategy
Pietersen K; Parsons R

A project was initiated during 2000 to synthesize the current knowledge about the Table Mountain Group (TMG) aquifer systems. This resulted in a document on the "Synthesis of the Hydrogeology of TMG – Formation of a Research Strategy." The document is subdivided into technical papers and appropriate case studies. This exercise resulted in the understanding that to realize the potential, of this groundwater supply, many uncertainties and barriers need to be overcome, including: deficient understanding of the occurrence, attributes and dynamics of TMG aquifer systems; lack of understanding of environmental impacts of exploitation; and uncertainties about how best to manage the resource within a multi-objective environment. Research of a multi-disciplinary nature is thus needed to find appropriate answers to questions concerning the water resource potential and optimal management of TMG aquifers, in the interest of furthering integrated water resource management in the region.

Report No: TT 158/01
ISBN: 1 86845 804 0
Overseas price: $40-00 excl postage

Learning about participation in IWRM: A SA review: Book 1 and 2 (also available in Venda, Sotho and Zulu)
Burt J; du Toit D; Pollard S

Report No: TT 293/06
ISBN: 1 77005 506 1
Overseas price: $20-00 excl postage

Research on Berg river water management: Summary of water quality information system and soil quality studies: (Integrated Catchment Management: ICM).
Gorgens AHM; de Clercq WP

This report describes the development of an integrated information system specifically for water quality (WQIS) for the Berg River that is both integrated and interactive. The WQIS has been developed in close cooperation with its intended technical users to provide water resource operational and planning decision support. The WQIS has a user-friendly GIS-based Graphical User Interface and incorporates interfaces with DUFLOW and CE-QUAL-W2. It was applied to the proposed Skuifraam Dam in the Upper-Berg to illustrate its utilisation to support decision-making for various in-dam water quality management scenarios.

Also reported are field-scale process studies and large-scale soils data interpretation, with a strong focus on salinisation processes. The main products are a soils map and a salinity hazard map that were compiled for the Berg River catchment.

Report No: TT 252/07
ISBN: 1 77005 367 0
Overseas price: $30-00 excl postage

Developing and trailing guidelines for participatory water resources management
Rowntree K; Motteux N;

South Africa's National Water Act of 1998 makes the management of any water resource a partnership between local water users, regional catchment managers, and DWAF. The Act encourages communities to become actively involved in developing and managing their water resources. The three sets of guidelines - Participatory Guidelines, Environmental Guidelines, Planning and Economic Guidelines – are aimed at IWRM practitioners who work with stakeholder communities. The guidelines help practitioners make participatory water resource management a reality.

Report No: TT 258/07
ISBN: 1 77005 064 7
Overseas price: $20-00 excl postage

A study of Roman water law, with specific reference to water allocations and prior appropriation.
Burger A

In view of the common law of South Africa being Roman-Dutch and Roman law, the question was asked: Can the Roman law provide some guidance

for water law and water allocations in South Africa in as much as the Roman law represents principles developed and successfully applied for almost a thousand years. The principles of Roman law were developed over a very long period in the vast Roman Empire, which covered a number of different countries with widely different climates. The final version of the Roman law is contained in the Corpus Juris Civilis compiled under the direction of the Emperor Justinian around 534 AD. The law of all European, and many other countries grew out of Roman law. It is, with Roman-Dutch, the common law of South Africa. That part of the Roman law constituting the principles of the water law is set out in this article. Before a law has withstood the test of years of practice, one cannot say whether it is a successful law or not. The Roman interdicts offer practical, tested guidance for resolving conflicts arising in water-stressed situations typical of arid and semi-arid areas. This makes the body of Roman water law worthy of attention and further study for application in South Africa, particularly as we approach full-scale implementation of the National Water Act.

Report No: TT 279/06
ISBN: 1 77005 469 3
Overseas price: $20-00 excl postage

Hydrogeology of groundwater region 26 Bushmanland
Vegter JR

This report forms part of a series on the hydrogeology of the various groundwater regions in South Africa. Region 26 (Bushmanland) is the fifth region that will be published; there are 64 Groundwater Regions. The Regions previously published are: 1 (Makoppa dome), 3 (Limpopo Granulite-Gneiss belt), 7 (Polokwane/Pietersburg Plateau) and 19 (Lowveld). The hydrogeology of the Bushmanland Region is described using available data and gives a good overview of the groundwater conditions in this region.

The main findings indicate that with decreasing rainfall and an increase in thickness of the superficial deposits there is a corresponding though not uniform deterioration in groundwater conditions from east to west. The report lists the conditions at which potential water strikes can be encountered. The data revealed that weathering enhances secondary porosity only where the water levels are less than about 30 metres deep. Water is generally struck in fractured fresh rock below the weathered zone and not in the transition between weathered and fresh rock as is the case in the higher rainfall areas. Seventy-four percent of groundwater samples, out of 968 samples, tested were unsuitable for domestic use. The constituents of concern in the groundwater are, in order of frequency of occurrence: fluoride, nitrate, chloride, sodium and sulphate. In most instances if a borehole produces significant water then the poor quality of the water becomes a limiting factor for development.

Report No: TT 285/06
ISBN: 1 77005 495 2
Overseas price: $40-00 excl postage

Groundwater Research needs in the Eastern Karoo Basin of South Africa
Murray EC; Cobbing JE

The main aim of the report is to outline the current groundwater research needs in the densely populated, impoverished eastern regions of the Eastern Cape Province. Groundwater is the main source for community water supply in the rural areas. Little groundwater research has been done to date in the eastern regions of the Eastern Cape Province – an area that comprises the Eastern Karoo Basin (the geological term for this region). The focus area of this document is Water Management Area 12, incorporating most of the former Transkei and Ciskei 'homelands'. This document describes how new research will coincide with national and provincial development priorities. It takes into account past research, proposes broad research areas, and finally, it lists what are considered to be the most important geohydrological research projects completed to date. It was developed after widespread consultation that included officials from the Department of Water Affairs and Forestry (DWAF) in the Eastern Cape Province, and a number of locally-based groundwater and engineering consultants.

Report No: TT 286/06
ISBN: 1 77005 497 0
Overseas price: $25-00 excl postage

Integrated water resource management plan guidelines for local authorities (IWRMP)
Burke J

From a groundwater perspective, Groundwater Resource Directed Measures (GRDM) is more important that the Reserve on its own. While the Reserve only addresses the role groundwater plays in meeting basic human needs and sustaining aquatic ecosystems such as rivers and wetlands, GRDM allows the use and protection of the entire groundwater resource to be addressed holistically. Four levels of GRDM assessments are recognised – desktop, rapid, intermediate and comprehensive – each providing an increased level of confidence.

The objectives of this project were:

- To review and implement methods developed to set RDM for groundwater through an appropriate case study;
- To refine and adapt methods as a result of lessons learnt during the pilot study; and
- Align methods with other components of RDM (e.g. estuaries, rivers and wetlands).

The E10 catchment containing the Olifants River was selected as the pilot study area. A Groundwater Resource Directed Measures assessment was undertaken. Additional data and information was collected, through a hydro census, for the study area where data was lacking. The research resulted in the development of the GRDM manual that can be used as a guide by both experienced and inexperienced geohydrologists to undertake and review GRDM assessments. Accompanying software was developed to assist with the assessments

Report No: TT 299/07
ISBN: 978 1 77005 510 0Overseas price: $30-00 excl postage

Groundwater Sampling: a comprehensive guide for sampling methods: Second edition
Weaver JMC; Cave L; Talma AS

This revised edition incorporates a number of additional sections, such as sampling for isotopes, down-hole logging, etc. Some chapters have been substantially revised to include advances in field instrumentation, such as pH meter technology and increased attention to organic compounds. A short chapter on the sampling of wetlands, springs and groundwater seeps has also been included. Other chapters have undergone only minor changes, since what was relevant in 1992 is today still relevant. Groundwater quality data collected according to these described techniques can then reliably be used to evaluate hydro geochemical conditions

Report No: TT 303/07
ISBN: 978 1 7005 545 2
Overseas price: $2-00 excl postage

KSA 2:

Estuaries and Integrated Development Planning: A Managers' Guide
Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07
ISBN: 978 1 77005 541 4
Overseas price: $15-00 excl postage

An introduction to Aquifer dependent Ecosystem in South Africa
Colvin C; Le Maitre D; Saayman; Hughes S

Aquifer Dependent Ecosystems (ADE) occurs throughout the South African landscape, but their identification is often difficult although this is relevant for water management and allocation. ADEs have been categorised by 8 principal aquifer types (based on lithology) and 7 habitat types. At a coarse national scale it is possible to identify areas with a high probability of supporting terrestrial and aquatic ADEs and to assess their vulnerability to disturbance. High areas of risk are linked to shallow discharge zones where over abstraction is taking place and mining and irrigated agriculture dominate land-use. South Africa is moving towards IWRM and ADEs need to be considered in this context. The successful protection of ADEs requires cooperative governance of land, water and the environment.

Report No: TT 301/07
ISBN: 978-1-77005-532-2
Overseas price: $ 25-00 excl postage

Learning and teaching about water in our classrooms: A series of lesson plans for grades 8-10
Peddie C; Hibbert D; Conway-Physick C

In support of learning and teaching about water=related issues, the Water Research Commission of South Africa and Share-Net (a project of the Wildlife and Environment Society of South Africa) have developed a series of lesson plans on water. These lesson plan packs, from Grade 8 to 10, are linked to the South African National Curriculum. All the lesson plan packs (Grade R-8) are available on www.envirolearn.org.za Other useful websites are the Water Research Commission: www.wrc.org.za and the Wildlife and Environment Society of SA www.wessa.org.za

Report No: TT 346/08
ISBN: 978 1 77005 693 0
Overseas price: $30-00 excl postage

Learning and teaching about water in our classrooms: A series of lesson plans for grades R-7
Clare P; Hibbert D; Conway-Physick C

Report No: TT 345/08
ISBN: 978 1 77005 650 3
Overseas price: $30-00 excl postage

WET-Roadmap: A guide to the wetland management series
Dada R; Kotze D; Ellery W; Uys M

This programme, co-funded by Working for Wetlands, aims to establish national wetland rehabilitation procedures by establishing a framework within which wetlands requiring rehabilitation may be prioritised and continually assessed. It will develop a diagnostic framework for assessing the underlying causes of degradation and develop national guidelines for rehabilitation including a review of the methods available. It will also develop synergy with other research being done on wetlands, examine the institutional arrangements around wetland management, and develop a long-term monitoring system that will allow strategic adaptive management of wetlands.

Report No: TT 321/07
ISBN: 978 1 77005 632 9
Overseas price: $10-00 excl postage

Guidelines for the planning, design and operation of fishways in South Africa
Ralph Heath, Anton Bok, Pieter Kotze, Paul Fouche, Hylton Lewis, Jan Rossouw, Mathew Ross

The need to manage water has led to the construction of barriers in rivers, effectively fragmenting the habitat and curtailing the passage of migratory biota.

This project will develop protocols for assessing the extent of blockage to free passage, and so prioritizing river systems for remedial measures, for the assessment of sites for use in the EIA and the RDM process. Understanding of the biological / hydraulic requirements of the relevant biota will be developed and this, together with data from existing fish-ways, will be used to develop cost-effective designs for local biota.

Report No: TT 287/07
ISBN: 978 1 77005 577 3
Overseas price: $30-00 excl postage

Hydrology and water quality of the Mgeni catchment
Kienzle SW; Lorentz SA; Schulze RE

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 87/97
ISBN: 1 86845 297 2
Overseas price: $30-00 excl postage

The biological and chemical database. User manual (SA Price: R28.50)
Dallas H & Janssens P

A Biological/Chemical Database was developed as part of this project, incorporating virtually all the ecological studies done on South African rivers which include both taxonomic and chemical data. Using SASS4 (South African Scoring System, version 4), several of the water-quality variables in the DWAF guidelines for environmental water quality were tested for each of the four regions (mountain, foothills, transitional and low land rivers).

Report No: TT 100/98
ISBN: 1 86845 421 5
Overseas price: $50-00 excl postage

Guides to the freshwater Invertebrates of Southern Africa

The principle aim of the series of ten books is to synthesize much of the existing knowledge on the identification of freshwater invertebrates into a standard format that is accessible to users who wish to identify taxa beyond their field of expertise. This series will include an introductory volume containing general information and a key to the families of invertebrates.

Volume 1: In preparation
Volume 2: Guides to the freshwater Invertebrates of Southern Africa: Crustacea I (SA price: R50.00)
Day JA, Stewart BA, De Moor IJ & Louw AE

Report No: TT 121/00
ISBN: 1 86845 581 5
Overseas price: $25-00 Postage inclusive

Volume 3: Guides to the freshwater Invertebrates of Southern Africa: Crustacea II (SA price: R50-00)
Day JA, Stewart BA, De Moor IJ & Louw AE

Report No: TT 148/01
ISBN: 1 86845 703 6
Overseas price: $25-00 Postage inclusive

Volume 4: Guides to the freshwater Invertebrates of Southern Africa: Crustacea III (SA price: R50-00)
Day JA, Stewart BA, De Moor IJ & Louw AE

Report No: TT 141/01
ISBN: 1 86845 676 5
Overseas price: $25-00 Postage inclusive

Volume 5: Guides to the freshwater invertebrates of Southern Africa: Non-Arthropods (SA Price: R114-00)
Day JA & IJ deMoor

Report No: TT 167/02
ISBN: 1 86845 827 X
Overseas price: $50-00 Postage inclusive

Volume 6: Guides to the freshwater invertebrates of Southern Africa: Arachnida & Mollusca: Araneae, Water Mites & Mollusca (SA Price: R50-00)
Day JA &IJ deMoor

Report No: TT 182/02
ISBN: 1 86845 875 X
Overseas price: $50-00 Postage inclusive

Volume 7: Guides to the freshwater invertebrates of Southern Africa: Insecta; Ephemeroptera, Odonata & Plecoptera (SA Price: R114-00)
IJ de Moor, JA Day & FC de Moor

Report No: TT 207/03
ISBN: 1 86845 875 X
Overseas price: $50-00 Postage inclusive

Volume 8: Guides to the freshwater invertebrates of Southern Africa: (SA Price: R100-00)
de Moor IJ; Day JA; de Moor FC

Report No: TT 214/03
ISBN: 1 77005 055 8
Overseas price: $50-00 Postage inclusive

Volume 9: Guides to the freshwater invertebrates of Southern Africa: Diptera (SA Price: R100-00)
JA de Moor, AD Harrison & IJ de Moor

Report No: TT 201/02
ISBN: 1 86845 900 4
Overseas price: $50-00 Postage inclusive

Volme 10: Guides to the freshwater invetebrates of Southern Africa" (SA Price: R100-00)
Stals R; De Moor IJ

Report No: TT 320/07
ISBN: 978 1 77005 629 9
Overseas price: $50-00 Postage inclusive

The Kruger National Park Rivers research programme
C Breen, M Dent, J Jaganyi, B Madikizela, J Maganbeharie, A Ndlovu, J O'Keeffe, K Rogers, M Uys & F Venter

The Kruger National Rivers research programme is a co-operative undertaking by resource-use managers, funding agencies and researchers. It addresses the water quality and water quantity requirements of the natural environments of rivers, particularly those flowing through the Kruger National Park.

Report No: TT 130/00
ISBN: 1 86845 622 6
Overseas price: $35-00 excl postage

State of the Rivers Report
DWAF, WRC, CSIR, Mpumalanga Parks Board & Dept of Environmental Affairs

Between 1996 and 1999, the River Health Programme (RHP) conducted surveys on the three major river systems of Mpumalanga, the Crocodile, Sabie Sand and Olifants Rivers, including some of their tributaries.

The RHP collected and assessed a substantial body of data on the ecological health of these rivers during the surveys.

The following reports are available:
1) State of the Rivers Report: Letaba and Luvuvhu River Systems 2001 (TT 165/01)
2) State of the Rivers Report (TT 147/00)
3) State of the rivers report: Umngeni River and neighbouring rivers and streams. (TT 200 /02)

Report No: TT 147/00
ISBN: 1 86845 689 7
Overseas price: $20-00 excl postage

Ecological risk assessment guidelines (South African price: R50-00)
Claassen M, Strydom W F, Murray K & Jooste

Ecological risk assessment is a structured approach that describes, explains and organizes scientific facts, laws and relationships and provides a sound basis to determine sufficient protection measures and to develop utilization strategies. The risk assessment process has the potential to improve communication between scientists, managers and the public, thereby promoting mutual understanding and collaboration. Appropriate use of this guideline document will thus promote cooperative governance and sustainable development

Report No: TT 151/01
ISBN: 1 86845 721 4
Overseas price: $25-00 excl postage

The Botanical importance rating of the Estuaries in former Ciskei/Transkei
Colloty BM, Adams JB & Bate GC

Botanical importance refers to the contribution of the plants to the conservation status of an estuary. In this study botanical importance is the sum of functional importance, species richness, community richness and community type rarity.

Report No: TT 160/01
ISBN: 1 86845 790 7
Overseas price: $20-00 excl postage

Guidelines for Legionella levels in water: A code of practice
Pauline Coubrough

The guidelines are intended for use in South Africa, taking in account South African environmental conditions. International guideline documentation, results from outbreaks that have occurred throughout the world, and the National Legionella Action Group's research findings were used in the formulation of the guidelines.

Report No: TT 174/02
ISBN: 1 86845 846 6
Overseas price: $15-00 excl postage

Predicting water quality and biotic response in ecological reserve determinations
Malan H; Day JA

The management of water quality in the environmental Reserve is more complex than that of water quantity. The principal aim of this project is to examine the relationship between water quality and water quantity with particular reference to instream flow requirement assessments, and to produce a framework for the assessment of water quality in IFR studies. Secondary aims are to investigate how the Biobase database may be used in the assessment of water quality guidelines.

Report No: TT 202/02
ISBN: 1 86845 923 3
Overseas price: $30-00 excl postage

Prioritisation of South African estuaries based on their potential importance to estuarine-associated fish species
Maree RC; Whitfield AK; Quinn NW

This report presents a ranking of South African estuarine systems based on their importance to estuarine-associated fish species, and aims to facilitate the identification of South African estuaries with a high conservation priority, by placing all South African systems in a regional and national context.

Report No: TT 203/03
ISBN: 1 86845 979 9
Overseas price: $10-00 excl postage

Freshwater fish and human health: Overview guide
Heath R; du Preez H; Genthe B; Avenant-Oldewage A

This programme focuses on the development of a series of guidelines and protocols to promote and advocate the safe use of water with the aim to build awareness and to transfer technology to the public to minimise water-related health risks. This programme is intended to meet the needs of practitioners and will consider aspects of water use and health, hygiene, hazards and risks as well as epidemiological studies, communication protocols and education guidelines.

These projects are concerned with translating scientific data into accessible formats.

Report No: TT 212/04
ISBN: 1 77005 046 9
Overseas price: $20-00 excl postage

Freshwater fish and human health: Reference guide.
Heath R; du Preez H; Genthe B; Avenant-Oldewage A

Report No: TT 213/04
ISBN: 1 77005 047 7
Overseas price: $25-00 excl postage

Environmental water quality in water resources management
Palmer T; Berold R; Muller N

The release of harmful and potentially harmful substances into the environment has caused water quality problems worldwide. Toxicology offers a cost-effective way of measuring the likely impact of an effluent on the environment, in that it will identify whether the effluent is toxic, including any synergistic and antagonistic effects. This will allow for both the determination of the suitability of the effluent for discharge to be determined for licensing purposes, and for specific industries to monitor their compliance with license conditions.

Most toxicity tests measure acute effects and the chronic values are calculated empirically. The measurement of sub-lethal methods will, thus, provide accurate values on which to base decisions, so enhancing the capacity of managers to protect the water resource.

During this project new methods will be developed for quantifying the chronic effects of toxic effluents at sub-lethal concentrations.

Report No: TT 217/04
ISBN: 1 77005 083 3
Overseas price: $10-00 excl postage

The effect of water quality variables on aquatic ecosystems review
Dallas HF; Day JA

Water is a scarce resource in South Africa, and increasing population pressure has meant that the resource is heavily exploited and carries an increasing pollution load. Aquatic ecosystems are able to remediate a certain amount of pollution, but once this level has been exceeded then the ecosystem, together with its ability to remediate pollution declines.

Chapters 2 and 3 of the review provide a general introduction to the issue of water quality in relation to aquatic ecosystems. Chapters 4 to 12 synthesise what is known about the effects on aquatic ecosystems of specific physical attributes and chemical constituents. Specifically, these include temperature, turbidity, pH, total dissolved solids and dissolved oxygen. Organic enrichment, including bacterial contamination, as well as the effects of enrichment by specific nutrients are covered, as are biocides and trace metals. The last eight chapters examine the effect of different types of whole effluents or other specific disruptions resulting from human activities, including agriculture, aquaculture, engineering and construction with specific reference to river regulation, forestry, industrial effluents, mining and urban runoff.

Report No: TT 224/04
ISBN: 1 77005 131 7
Overseas price: $30-00 excl postage

Towards the conservation and sustainable use of Eastern Cape estuaries.
Breen C; et al

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 237/04
ISBN: 1 77005 235 6
Overseas price: $20-00 excl postage

Spatsim, an integrated framework for ecological reserve determination and implementation.
Hughes DA; Palmer CG

Water quality is currently trailing water quantity in the ecological Reserve methodology. Further development of the methods used is necessary to enable the water quality component to be considered adequately. The aims of this project are to develop acceptable time-series data for selected water quality variables, encapsulate the expert water quality knowledge in an organised way and encode these for inclusion into the DSS currently being developed as part of a parallel project, and co-ordinate this with other water quality projects working on the Reserve. This will ensure that decisions taken on water quality in the Reserve determination process are done in a standard way and in parallel with those on water quantity.

Report No: TT 245/04
ISBN: 1 77005 296 8
Overseas price: $25-00 excl postage

Managing sedimentary processes in SA Estuaries: A guide
Hay D; Huizinga P; Mitchell S

Ingress of marine sediments into estuaries was the single most important issue in estuary management identified in the western part of the Eastern Cape during the early stages of the EC Management Programme. The local authority for the Port Alfred / Boesmans River area has committed funds to develop the predictions of the effect of interventions on the problem. If the predictions indicate that an intervention may be successful, then the EIA around the planned

intervention will be undertaken within this project. Thereafter, the implementation of any technology will be for the expense of the local authority.

Report No: TT 241/05
ISBN: 1 77005 272 0
Overseas price: $20-00 excl postage

The SA diatom collection:

1. An appraisal and overview of needs and opportunities

Harding WR; Archibald CGM; Taylor JC; Mundree S

The South African Diatom Collection (which extends beyond South Africa's borders) was established over the period 1950 to 1995 by a number of collectors and is amongst the larger collections worldwide. A number of case studies were carried out which showed the relevance of the OMNIDIA software package (use of diatom-based water quality indices) for South African conditions. The general conclusion is that the data and information contained in this collection will add value to, and have a place in, the current suite of assessment tools currently being used for the management of the surface water resource in South and Southern Africa.

Report No: TT 242/04
ISBN: 1 77005 275 5
Overseas price: $25-00 excl postage

2. Benthic diatoms in the rivers and estuaries of South Africa

Bate GC; Smailes PA; Adams JB

This follow-on project (from the project entitled Identification of diatoms and their use in the assessment of water quality) will address 3 aspects of the use of diatoms in monitoring for water quality. The determination of the relationship between dominant diatom assemblages and freshwater quality will continue. The same will be done for estuarine diatoms, where the relationship between water quality and dominant assemblages will be defined. Thirdly, a manual of South African diatoms will be produced. The product of this project will enable the use of diatoms, long recognised as being sensitive indicators, in water quality management at the technician level, not achieved elsewhere before.

Report No: TT 234/04
ISBN: 1 77005 182
Overseas price: $35-00 excl postage

3. A methods manual for the collection, preparation and analysis of diatom samples.

Taylor JC; Harding WR; Archibald CGM

Report No: TT 281/07
ISBN: 1 77005 483 9
Overseas price: $20-00 excl postage

4. An illustrated guide to some common diatom species from South Africa.

Taylor JC; Harding WR; Archibald CGM

Report No: TT 282/07
ISBN: 1 77005 484 7
Overseas price: $30-00 excl postage

The state of Yellowfish report in South Africa: (SA price R50-00)

Wolhuter LE; Impson ND

Report No: TT 302/07
ISBN: 978 1 77005 543 8
Overseas price: $30-00 excl postage

Cross-sector policy objectives for conserving South Africa's inland water biodiversity.

Roux D; Nel JL; MacKay HM; Ashton PJ

Report No: TT 276/06
ISBN: 1 77005 459 6
Overseas price: $25-00 excl postage

Conservation planning for river and estuarine biodiversity in the Fish to Tsitsikamma water management area.

Lindsay NJ, Smith-Adao L, Roux DJ, Adams J, Cambray JA, de Moor FC, Kleynhans CJ, Kotze I, Maree G, Moolman J, Schonegevel LY, Smith RJ, Thirion

This study piloted the development of a planning framework for systematic conservation of inland water biodiversity in South Africa. The tool for river prioritization and selection was tested, refined and demonstrated in the Fish to Tsitsikama Water Management Area, and provides a process for implementing biodiversity conservation in practice.

Report No: TT 280/06
ISBN: 1 77005 473 1
Overseas price: $30-00 excl postage

Estuaries and Integrated Development Planning: A Managers' Guide

Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07
ISBN: 978 1 77005 541 4
Overseas price: $15-00 excl postage

KSA 3:

Community-based governance of freshwater resources in Southern Africa.

Sharon Pollard, T Cousins

One result of the process of democratisation is legal pluralism in areas of communal tenure, in that the traditional locally-derived rules and norms for natural resource management run in parallel to statutory systems. In addition, South Africa is about to implement reforms in the statutory systems aimed at brining about equity and sustainability. Within this complex social system, this project aimed to examine governance options for community based natural resource management in communal areas.

This project contributed to the growing discourse on legal pluralism in water management through examining local or customary, laws in practice, focusing on water resource management. The research reviewed the status of community governance of water resources in four SADC countries (South Africa, Mozambique, Zimbabwe and Zambia), and documented the complementarities and tensions between statutory and customary systems in these countries. One lesson from these countries is that where the implementation of national legislation is weak, people revert to the traditional governance structures.

The reality is that legal pluralism will be part of the South African Water governance landscape for some

time to come, and internationally based research has warned that the 'neglect of customary laws may cause IWRM implementation to fail, or will have negative consequences for individuals and groups who were better served by customary-based systems – especially the poor'. The report concludes that we should not be constrained by a few idealized models of centrally managed water. Preferably let us seek innovative ways to integrate, or embed, common-property regimes with the formal, statutory system.

Report No: TT328/08
ISBN: 978 1 77005 674 9
Overseas price: $20-00 excl postage

Standard methods for the recovery and enumeration of Helminth Ova in wastewater, sludge, compost and urine-diversion waste in South Africa.
Priya Moodley, Colleen Archer, David Hawksworth and Lizette Leibach

These Guidelines detail a new classification system according to the microbiological class, stability class and pollutant class and total viable Helminth Ova have been added in the microbiology class. The Guidelines do not specify the analytical methods and as a result, different laboratories adopted
different methods in South Africa. This project aims to validate a new EPA method for measuring Helminth Ova in wastewater and wastewater sludge. The method and related literature with sufficient visual material will be documented and used to build capacity in South African water and wastewater laboratories to measure all Helminth Ova in wastewater sludge and wastewater samples.

Report No: TT 322/08
ISBN: 978 1 77005 648 0
Overseas price: $25-00 excl postage

Condensed laboratory methods for monitoring phytoplankton, including cyanobacteria, in South African freshwaters.
Swanepoel A; du Preez HH; Schoeman C; J van Vuuren S; Sundram A

The project will compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins, Geosmin and MIB for South African freshwaters Current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis, as well as for Geosmin and MIB analysis will be synthesized and a summarized reference document compiled.

Report No: TT 323/07
ISBN: 978 1 77005 684 8
Overseas price: $25-00 excl postage

Aqualite Water Balance Software – User Guide
Roland Scott McKenzie

The methodologies used in AquaLite draw strongly on recent recommendations of Task Forces of the International Water Association (IWA). It should be noted that the methodologies for quantifying water losses contained in the AquaLite model are not the only methods used worldwide. They are, however, well accepted and used extensively in many parts of the world and are rapidly being recognised as the most appropriate and pragmatic techniques for assessing the water balance components for potable water distribution systems. AquaLite also includes the calculation of the Unavoidable Annual Real Losses (UARL) as well as the use of the Infrastructure Leakage Index (ILI) as a key performance indicator. These two parameters are currently the subject of considerable attention and debate throughout the world and are being used in many countries. When used properly they can provided very useful information on the performance of a water distribution system but must be used with care to ensure that the results are meaningful since there are situations where the estimates can be misleading.

Report No: TT 315/07
ISBN: 978 1 77005 599 5
Overseas price: $10-00 excl postage

Water Services and HIV / AIDS; Integrating health and hygiene education in the water and sanitation sector in the context of HIV/AIDS (PLEASE DOWNLOAD FROM WEB: www.wrc.org.za)
Clacherty A; Potter A

This Water Research Commission study (Project K5/1634) arose from a growing realisation that, in relation to water and sanitation infrastructure development projects, there is little consistency or coherence of approach to health and hygiene education (H&HE). As a result, many interventions are ineffectual. Further, the linkages between HIV/AIDS and the improvement of water and sanitation facilities and related H&HE are poorly addressed in this country. The response involved considerable research over a period of time. It has identified factors which constrain and enable effective implementation of project-based H&HE in the context of HIV/AIDS. Based on that research and understandings of the context, it has developed and tested various institutional and financial arrangements and developed implementation models based on this work. The study places considerable emphasis on the linkages between water and sanitation, heath and hygiene education and HIV/AIDS. The impact of HIV/AIDS on the lives of many South Africans is severe; it is imperative that the water services sector formulates and implements an appropriate response as a matter of urgency. It is critical that issues around HIV/AIDS are mainstreamed, both in terms of prevention as well as in reducing the impact on people living with AIDS. Caregivers, in particular, require not only knowledge of water and sanitation and related health and hygiene issues, but also access to adequate quantities of water of good quality.

Report No: TT 316/07
ISBN: 978 1 77005 602 2
Overseas price: $20-00 excl postage

Report No: TT 317/07
ISBN: 978 1 77005 603 9
Overseas price: $20-00 excl postage

The assessment of training programmes and capacity needs for the water sector: Executive summary
Mjoli N; Schoeman G

The South African Government has committed itself to an ambitious target of eliminating the water and sanitation services backlog by 2008 and 2010, respectively. However, the current skills shortage at the local government level poses a threat to the achievement of the water and sanitation delivery targets. The slow rate of delivery is largely due to inadequate technical skills in most municipalities. The problem is particularly acute within rural municipalities which have the lowest resource base and, at the same time, have the highest sanitation backlog figures.

The shortage of skills is not limited to the water services sector; the water resources management sector faces a similar problem. There is a growing concern among sector stakeholders that the current approaches to skills development are not producing the numbers of skilled people that are needed to improve the performance of municipalities. This situation calls for a review of the current practices in skills development and training provided by public and private providers in order to identify factors that are hampering accelerated skills development, despite the availability of large budgets from the skills development fund.

Report No: TT 306/07
ISBN: 978 1 77005 554 4
Overseas price: $10-00excl postage

Standardisation of the use of particle counting for potable water treatment in SA
Ceronio AD; Haarhoff J; Pryor M

Turbidity is a gross measure of the quality of potable water. Particle counting and size analysis is fundamental to a deeper understanding of flocculation, settling and filtration processes. The primary objective of water treatment is the removal of particles. This project investigated the use of particle size analysis as a control parameter for the optimisation of water quality, and compared this to the control using zeta potential and streaming current. It studied the effects of pretreatment processes such as ozonation and coagulation on the clarity of the filtered water by measuring particle size; and considered the use of particle size analysis together with CFD for the optimisation of water treatment equipment. The report stresses the importance of standardisation of this technology and also includes a substantial amount of fundamental principles and practices useful to potential users considering the implementation of this technology.

Report No: TT 166/01
ISBN: 1 86845 801 6
Overseas price: $20-00 excl postage

An illustrated guide to basic water purification operations.
Bouwer JL; Haylett

Lack of skills because of lack of training was identified as one of the most important hindrances to the supply of good quality potable water, especially in rural areas. Suitable training material is not available and current training material is inadequately targeted for rural operator training. A cartoon based operator manual for sewage plant operator training had previously been completed and proved to be a big success. Therefore, it was seen as appropriate to complete a similar guide for operator training on, especially, small to medium sized water treatment plants

Report No: TT 247/05
ISBN: 1 77005 323 9
Overseas price: $30-00 excl postage

Corporatisation of municipal services providers
Development group; University of Western Cape

The restructuring of municipal water departments into stand-alone companies has been a long-standing subject of debate within the industry. This study aimed to further explore the concepts of corporatisation and its relevance to the South African water sector by, combining an international literature review with local case studies and policy reviews. The research concludes that corporatisation in itself does not guarantee performance. Whilst a shift in legal form from a municipal department to a stand-alone legal entity can make a difference, this is not the only or major determinant of performance. Various objective factors and broader governance factors are likely to have a greater impact than simply the legal form of the utility. Further corporatisation may be a suitable option for some municipalities. For capacity reasons corporatisation is only likely to be feasible within the large metro poles at this stage. As the experience base grows within South Africa, and transaction costs diminish, corporatisation may become feasible for smaller local authorities. This study highlights that before embarking on a corporatisation process municipalities should assess whether they have sufficient financial, managerial and political capacity to see the process through.

Report No: TT 199/02
ISBN: 1 86845 897 0
Overseas price: $25-00 excl postage

Management of water-related microbial diseases.
DWAF; WRC

The purpose of this guideline series is to provide awareness building and management information on the nature and prevention of important water-related microbial diseases.

The purpose of volume one in the series, "Disease characteristics", is to introduce and describe the basic facts of some important water-related diseases. This guide is primarily an awareness building guide to educate the upcoming generation in the need for: (1) disinfected drinking water, (2) safe waste disposal, (3) good personal and kitchen hygiene, and (4) protection of water resources from faecal pollution.

Report No: TT 175/03
ISBN: 1 86845 849 0
Overseas price: $25-00 excl postage

1. Guidelines for the appropriate management of urban runoff in SA
Ashton PJ; Bhagwan JN

As the aim of this study was to establish general guidelines for the management of urban runoff water quality, especially focusing on dense settlements, urban runoff quality is a country-wide problem, the causes of which must be addressed. Past attempts to intercept urban storm water and channel it through a single storm water system to receiving water have failed. As storm water quality may be worse than treated sewage effluent and sometimes even raw sewage, treatment of storm water at some stage before discharge to the receiving waters has to be considered. Present engineering storm water management options do not cater for improving storm water quality. The impact of low-cost, high-density urban land use on the catchment warrants serious attention. Appropriate sanitation and waste disposal for peri-urban areas requires fundamentally new approaches. It is imperative therefore that applied research into these areas be conducted for the protection of South Arica's limited water resources.

Report No: TT 155/01
ISBN: 1 86845 764 8
Overseas price: $15-00 excl postage

2. Expert system for design of storm water management systems for urban runoff quality
Coleman TJ

Report No: TT 156/01
ISBN: 1 86845 768 0
Overseas price: $15-00excl postage

PRESMAC: Development of a pragmatic approach to evaluate the potential savings from pressure management in potable water distribution systems in South Africa. (Presmac User Guide Version 1.1)
McKenzie R; Lambert A

This document incorporates the user guide to the South African Pressure Management and Control (PRESMAC) model which has been developed through the Water Research Commission (WRC) funded project titled "The Water Leakage: Pressure Management Model".

The PRESMAC model represents one of several models that are being developed through the WRC in order to assist water suppliers to manage and reduce their levels of unaccounted-for water. The models are supplied free-of-charge through the WRC for use within South Africa and further details can be obtained from the WRC web site on: http://www.wrc.org.za.

Report No: TT 152/01
ISBN: 1 86845 722 2
Overseas price: $20-00 excl postage

Financial planning for infrastructure services at district level: A user guide to the district services model. Version 1.1
Palmer Development Group

This manual outlines the philosophy behind the model, its aims, limitations and key assumptions. The structure and operation of the model is described in detail, covering the required data inputs and the meaning and presentation of the various outputs.

The District Services Model (DSM) has been designed to assist district municipalities to undertake financial analysis of infrastructure investment plans. The model performs this analysis at two levels:
Level 1: District-wide infrastructure planning, and
Level 2: Medium-term Council budgeting.

Report No: TT 143/01
ISBN: 1 86845 680 3
Overseas price: $15-00 excl postage

A guide to non-point source assessment to support water quality management quality of surface water resources in SA
Pegram GC; Gorgens AHM

The primary focus of this guide is to support water quality management of surface water resources, and particularly non-point sources management, through the provision of appropriate and cost-effective information for dicision-making.
Report No: TT 142/01
ISBN: 1 86845 677 3
Overseas price: $20-00 excl postage

The Development of Effective Community Water Supply Systems using deep and Shallow Well Hand pumps.
Hazelton DG

Deep- and shallow-well hand pumps are used extensively for rural community water supplies over large parts of South Africa. Very often, however, these installations fail to meet the requirements even though they are considered to be one of the simplest community water supply technologies.

It has, however, been demonstrated in other parts of the world that high failure rates are not inevitable and that these schemes can be transformed into reliable low-cost solutions through the adoption of the so-called village level operation and maintenance (VLOM)-concept, where appropriate design technologies and implementation policies are systematically included. The study indicated that 10% of the South African populations (2 million people) are dependent on the estimated 10 000 hand pumps which exist in this country. This can be equated to an investment of about R400 million, and the study estimates that between 40% and 50% of the hand pumps are not working at any one time.

Report No: TT 132/00
ISBN: 1 86845 629 3
Overseas price: $25-00 excl postage

Applicability of waste minimisation clubs in South Africa: Results from pilot studies.
Barclay S; Buckley C

Industrial small-, medium- and micro-enterprises (ISMMEs) are a strategic growth sector in the RSA but cumulatively are significant sources of pollutants which detrimentally affect sewage treatment. The overall objective of the project was the development of regional waste minimization clubs, in which cleaner production practices can be cost-effectively established as a contribution to the sustainability in South Africa of ISSMEs that are both competitive and environmentally responsible.

Report No: TT 161/05
ISBN: 1 86845 831 8
Overseas price: $30-00 excl postage

Guidelines for the utilisation and disposal of wastewater sludge: Volume 1 of 5: Selection of management options.
Snyman HG; Herselman JE; Kasselman G; Steyn CE; Wilken JW

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 261/05
ISBN: 1 77005 422 7
Overseas price: $20-00 excl postage

Guidelines for the utilisation and disposal of wastewater sludge: Volume2 of 5: Requirements for the agricultural use of wastewater sludge
Snyman HG; Herselman JE; Kasselman G; Steyn CE; Wilken JW

Report No: TT 262/05
ISBN: 1 77005 423 5
Overseas price: $20-00 excl postage

Water purification works design: (SA Price R150-00)
Van Duuren FA

This project was aimed at facilitating the optimal, most economical water purification and treatment works by providing a design guide based on water quality considerations, processes and operations. This guide indicates water quality requirements, control and management of procedures, and water demands in all sectors. It also categorises water purification and treatment processes and operations

Report No: TT 92/97
ISBN: 1 86845 345 6
Overseas price: $50-00 excl postage

Information transfer extraction management systems (ITEMS)
(SA Price R114-00)
Howard MR; Perkins M

This project developed a computerised Information Transfer, Extraction and Management System (ITEMS) which enables users to gain access to local and international information on mine-water quality, management, treatment and research. The six modules incorporated in ITEMS, viz. literature, water quality guidelines, contaminant properties, research results, an impact assessment manual and a mine-water management manual, and the options available in each of the modules, renders ITEMS an extremely versatile information tool. The total computer file size of the databases is 87 Mbytes. ITEMS is available on CD-ROM

Report No: TT 94/98
ISBN: 1 86845 378 2
Overseas price: $70-00 excl postage

Solids-free sewer systems in South Africa: a community leader's guide
Du Pisani JE

This study evaluated the STED systems in South Africa. It showed that STED systems were used on over 16 000 erven in South Africa. The study showed that problems experienced with these systems were mainly due to poor operation and maintenance and some incidents of blockages were due to incorrect design and construction of the STED systems. The study concludes that with proper design, operation and maintenance, STED systems offer a cheaper alternative of meeting the sanitation needs of. The output of this research includes two guidelines, namely Operation and Maintenance of Solids-free Sewer Systems in South Africa: Guidelines for Engineers; and Solids-free

Sewer Systems in South Africa: A Community Leader's Guide

Report No: TT 96/98
ISBN: 1 86845 401 0
Overseas price: $20-00 excl postage

Handbook to guide communities in the choice of sanitation systems
Bernhardt Dunstan & Associates

The main aim of this study was to evaluate on-site sanitation systems from a socio-economic perspective with special reference to affordability, appropriateness and social acceptability. The study was undertaken in three case study areas, namely, Soshanguve TT, Ivory Park and Ga-Mmotla. The study concluded that in all three case study areas, communities were dissatisfied with their on-site sanitation systems. Women were unhappy about being excluded from decision-making on the selection of sanitation technologies, because as the main users, they are better qualified to select a sanitation system that could be operated and maintained by the users.

Report No: TT 104/98
ISBN: 1 86845 425 8
Overseas price: $10-00 excl postage

Guidelines for the design and operation of sewage sludge drying beds
Ceronio AD; Van Vuuren LRJ; Warner APC

Current information and guidelines for the design and operation of sewage sludge drying beds in the RSA are very limited. The design data available are largely empirical and give almost no insight into the effect of climate, sludge concentration, loading rates, sludge volume index, filter media, etc. on the drying bed area required. Based on the research and support of experimental work done, as well as information obtained from literature, the study produced a guideline that is specific for South African conditions called Guidelines for the Design and Operation of Sewage Sludge Drying Beds (WRC Report No TT 107/99)

Report No: TT 107/99
ISBN: 1 86845 491 6
Overseas price: $25-00 excl postage

Guidelines for the calibration of measuring flumes in sewers
Rooseboom A; Goodey GM

During 1992 a detailed investigation revealed that the majority of open channel flumes on South African sewer mains and at municipal wastewater treatment plants, do not comply with the generally accepted British Standards 3680. In this project tests were performed on different flumes in order to establish the impact of differences in shape and surface roughness on calibration coefficients. These guidelines are the product of a large number of practical tests, combined with existing standards for the measuring of fluids by flumes. The result is a set of methodologies and worked examples, which clarifies and simplifies measuring flume design to the point where plant personnel in the smaller plants will also be able to follow and utilise the guidelines to the full.

Report No: TT 111/99
ISBN: 1 86845 501 7
Overseas price: $25-00 excl postage

Corrosion brochure for local authorities
Ramotlhola JS; Ringas C

The brochure highlights cost-effective ways in which external corrosion can be minimised. The brochure can also be useful to repair teams working in the field. The brochure contains colour photographs showing the different forms of corrosion in order to assist field teams to correctly identify the cause of the failure. Appropriate repairs can then be carried out. The brochure also describes how each local authority can build up its own database, thereby assisting in the long-term strategy of each local authority by ensuring that correct corrosion prevention strategies are used.

Report No: TT 112/99
ISBN: 1 86845 510 6
Overseas price: $15-00 excl postage

DOMESTIC WATER SUPPLY: GUIDES

The provision of an adequate and safe water supply to all people is one of the goals of the South African Government. To ensure the safety of water supplies, a need for a user-friendly Guide to facilitate evaluation of the health-related quality of water supplies was identified as a priority by both the Departments of Health and Water Affairs and Forestry. This resulted in the production of a series of guides.

This Guide forms part of a series which is intended to provide water supply agencies, water resource managers, workers in health-related fields, as well as communities throughout South Africa, with the information they need to sample, analyse, assess and interpret the quality of domestic water supplies. The following documents from the series:

Quality of domestic water supplies
Vol: I: Assessment Guide TT 101/98

Report No: TT 101/98
ISBN: 1 86845 416 9
Overseas price: $25-00 excl postage

Quality of domestic water supplies
Vol II: Sampling Guide1 TT 117/99

Report No: TT 117/99
ISBN: 1 86845 543 2
Overseas price: $15-00 excl postage

Quality of domestic water supplies
Vol III: Analysis Guide1 TT 129/00

Report No: TT 129/99
ISBN: 1 86845 620 X
Overseas price: $20-00 excl postage

Quality of domestic water supplies
Vol 4: Treatment guide TT 181/02

Report No: TT 181/99
ISBN: 1 86845 873 3
Overseas price: $30-00 excl postage

Quality of domestic water supplies –
Vol 5: Management Guide TT 162/01

Report No: TT 162/99
ISBN: 1 86845 809 1
Overseas price: $30-00 excl postage

The management of urban impoundments in South Africa volume 2. Guideline manual
Freeman MJ; Howard MR; Wiechers HNS

This Urban Impoundment Management Guideline Manual is the product of a research project carried out for the Water Research Commission to investigate the water- quality problems most commonly experienced in South African urban impoundments, as well as the management techniques which can be used to address them.

The purpose of the Guideline Manual is to assist those responsible for, or with an interest in, the management of the water quality of urban impoundments. It is thus aimed predominantly at those persons in local authorities who must manage the water bodies in their areas.

Report No: TT 119/00
ISBN: 1 86845 553 X
Overseas price: $25-00 excl postage

The economic cost effects of salinity - integrated report
Urban-Econ Development Economists

As the salt content of water increases, the water becomes less suitable for most users, and additional costs are incurred. The study was undertaken because of uncertainties about some of the methodology and assumptions that were used in the desk study and the need for a versatile economic model that can be used to quantify the effect of salinity in monetary terms and to compare the cost-benefit ratios of alternative options. A generic methodology to determine the financial, economic and social impacts associated with an increase in salt concentration were first developed, and then applied by conducting a survey to determine the impacts of increased salt concentrations in the middle Vaal River.

Report No: TT 123/00
ISBN: 1 86845 590 4
Overseas price: $20-00 excl postage

Defluoridation, denitrification and desalination of water using ion - exchange and reverse osmosis
Schoeman JJ; Steyn A

This project concentrated on demonstrating the feasibility of using advanced adsorption, ion-exchange and membrane technologies to remove fluorides, nitrates and dissolved suspended solids from groundwater in order to produce potable water for rural communities which are remote from first-world infrastructure. Activated alumina, ion-exchange and reverse-osmosis systems were evaluated at a number of rural sites in terms of both technical and social acceptance factors. The results achieved in these demonstration studies show that activated alumina and ion-exchange processes and advanced water treatment processes such as membrane filtration can be employed successfully for the purification of adverse-quality groundwater to potable standards in the rural areas.

Report No: TT 124/00
ISBN: 1 86845 597 1
Overseas price: $20-00 excl postage

Land -based effluent disposal and use: Development guidelines and expert systems-based decision support
Murphy K O'H

Effluents and soils were identified as factors which help in the process of making decisions on the applicability of a specific effluent on a specific land. The identification of the effluent takes into account health-related aspects, the risk of pollution to the water source and the effects of it on plants. The identification of the soil relates to the ability of soils to attenuate the contaminants in the effluents.

The user guide takes one through the process in order to be able to determine whether the combination is acceptable or not and whether it conforms to health guidelines. If this is acceptable, it is indicative of restrictions or protective measures. ELADS Effluents to land - application decision-support software is the expert systems-based decision-support software developed. It could be used not only for sewage effluents, but also for organic effluents, to some extent for nitrogenous effluents and effluents containing potentially toxic trace elements. It could be modified to accommodate any site, soil or effluent-related limits specified by new regulations. (WRC Report No TT 125/00).

Report No: TT 125/00
ISBN: 1 86845 551 3
Overseas price: $20-00 excl postage

The level of communication between communities and engineers in the provision of engineering services
Pybus P; Schoeman G; Hart T

The purpose of this research was to test the hypothesis above and to establish how engineering information, for example, concerning the level of service, can best be given so that the community leaders can make a decision based on sound knowledge of the technicalities of the situation. In an analysis of the major factors that negatively affect communication between consultants (specifically engineering) and communities, it was found that the majority of factors stemmed from a lack of integrated and comprehensive project planning.

The findings from this study are supported by an excellent set of guidelines, aimed at improving communication processes between practitioners and communities in water and sanitation development projects

Report No: TT 133/00
ISBN: 1 86845 630 7
Overseas price: $20-00 excl postage

Waste minimisation guide for the textile industry: A step towards cleaner production: Vol I
Barclay S; Buckley C

The Waste Minimisation Guide for the Textile Industry has been found to be a useful tool for assisting the RSA textile industry to improve its environmental performance in the following areas of application:

- The textile industry can use the Guide to self-assess and improve its implementation of waste minimisation practices and, hence, its aquatic environmental performance
- Similarly, use of the Guide will assist factories in achieving compliance with environmental management standards e.g. 1S0 14000, and, thereby, improving their international competitiveness
- Local regulatory authorities can use the Guide both as a training tool and as a management tool for monitoring and assessing the performance of textile manufacturers in their area of jurisdiction.

Report No: TT 139/00
ISBN: 1 86845 659 5
Overseas price: $20-00 excl postage

Waste minimisation guide for the textile industry: A step towards cleaner production. Vol II

Report No: TT 140/00
ISBN: 1 86845 659 5
Overseas price: $20-00 excl postage

Hygiene awareness workshop
Duncker LC

The study showed that the level of general knowledge regarding hygiene practices was high in all case study areas. However, the practice of appropriate hygienic lifestyle was hampered by poverty and a lack of access to basis water supply and sanitation services. It was found that rural communities lacked a specific knowledge regarding causes, transmission and prevention of water-related and faeces-related diseases. The level of knowledge on the treatment of these diseases was high because of their prevalence in these communities.

This research has produced the following manuals:
- A Manual on Knowledge, Attitude and Practice (KAP) Study for Hygiene Awareness in the Rural Areas of South Africa (K5/819)
- Hygiene Awareness Programme (TT144/00)

Report No: TT 145/00
ISBN: 1 86845 633 1
Overseas price: $25-00 excl postage

Human resources planning and management system (HRPMS) user manual
Stewart Scott

The study has developed a management tool to help managers to implement integrated human-resource planning of water service institutions. The report

focuses on the human resources that are required in order to support the infrastructure, as well as the organisational structure requirements of various sizes of water service institutions. The computerised human resources planning and management system (HRPMS), which was developed for water service institutions through this study, includes facets of both a management information system (MIS) as well as a decision support system (DSS). The management component of the HRPMS includes portions of the job analysis and employee profile modules. The reporting facilities provided by the HRPMS facilitate management, planning and decision-making.

Report No: TT 146/01
ISBN: 1 86845 686 2
Overseas price: $15-00 excl postage

Assessment of the attended coupon-operated access-point cost recovery system for community water supply schemes
Lima Rural Development Foundation

The study highlights parameters in which attended coupon operated access point cost recovery system operates efficiently by analyzing seven existing schemes. The research to identify the operational constraints that community water supply schemes are currently facing by conducting sample surveys in the schemes.

Report No: TT 150/01
ISBN: 1 86845 716 8
Overseas Price: $15-00 excl postage

Development of a simple and pragmatic approach to benchmark real losses in potable water distribution systems in South Africa: BENCHLEAK
Ronnie McKenzie & Allan Lambert

The BENCHLEAK software and this User Manual are part of the ongoing process of refining and improving the methodologies for calculating and presenting performance data associated with management of public water supply systems in South Africa.

Report No: TT 159/01
ISBN: 1 86845 773 7
Overseas Price: $20-00 excl postage

The BENCHLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: http://www.wrc.org.za

Development of a Windows based package for assessing appropriate levels of active leakage control in potable water distribution systems: ECONOLEAK
Ronnie McKenzie

The ECONOLEAK model is aimed specifically at determining when a water supplier should invest in active leakage control for a specific zone metered area.

Report No: TT 169/02
ISBN: 1 86845 832 6
Overseas Price: $20-00 excl postage

The ECONOLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: http://www.wrc.org.za

Guidelines for the implementation of benchmarking practices in the provision of water services in South Africa
Pybus P

The guidelines are intended to encourage the local authorities to benchmark their activities with their peers with a view to delivering water and sanitation services in a more effective and efficient manner.
Benchmarking offers a route to more effective and efficient service delivery.

Report No: TT 168/02
ISBN: 1 86845 842 3
Overseas price: $20-00 excl postage

Environmentally responsible mining: Water management guidelines for small-scale mining
Clacherty A; Moodie P

This report identifies and characterises the critical water-related impacts of small-scale mining and is developing appropriate tools to assist their environmental management. The study focused primarily on the water-related issues of peat extraction, clay-mining for brick making, alluvial diamond-mining and other small-scale mining activities associated with gravels, alluvial sands and sediments.

Report No: TT 170/04
ISBN: 1 86845 833 4
Overseas price: $20-00 excl postage

Guidelines for the application of natural stone trickling filters with some reference to synthetic media trickling filters
Wates, Meiring & Barnard (Pty) Ltd

Trickling filters are applied in many domestic and industrial wastewater treatment plants in Southern Africa. Trickling filtration technology is still evolving and this document provides current information on the design, operation and maintenance of filters.

Report No: TT 178/02
ISBN: 1 86845 852 0
Overseas price: $15-00 excl postage

Water and wastewater management in the oil refining and re-refining industry: NATSURV 15
CSIR

In this study the water intake, water use and pollutant loads of the crude oil refinery, synthetic fuel refinery and refining sectors of the industry were surveyed and characterised. Crude oil refineries in the RSA were found to have a relatively narrow range of specific water intake (SWI 0.51 to 0.67 m3/t) and re-refining SWIs were found to vary widely (0.06 to 7.2 m3/t), depending on the type of process used. The results obtained present a snapshot of the water and wastewater characteristics of the industry in which crude oil refining (at four refineries) is around 20 million t/a, syn-fuel refining (at two refineries) is around 9 million t/a and oil re-refining is around 120 000 t/a. In addition to the water and effluent survey data, the Guide produced contains a number of specific recommendations for reducing water use and effluent generation in the industry.

Report No: TT 180/05
ISBN: 1 86845 508 4
Overseas Price: $15-00 excl postage

Elementary handbook of water disinfection
Carlsson FHH

The salient features of the handbook covers:

- Description of water disinfection processes, principally chlorination and chloramination but including ozonation, peroxone, chlorine dioxide and ultraviolet treatments
- Written such that it is understandable by non-specialists in water treatment plants and informed lay-persons
- To be used as an aid in effective education and training of plant personnel while avoiding detailed chemistry
- To be used as a ready reference for daily use on water purification plants where disinfection is implemented.

Report No: TT 205/03
ISBN: 1 86845 983 7
Overseas price: $20-00 excl postage

Watrex expert system for water treatment plant design: (South African price: R500-00)
FR Sutherland

This is a Windows-based software package that applies expert system technologies to water treatment plant design. The software allows data acquisition, unit process design and modeling, process selection, and dynamically responding plant design, modeling and sensitivity analyses.

Report No: TT 206/03
ISBN: 1 77005 016 7
Overseas price: $200-00 Postage inclusive

An assessment of the trickle feed system as a tool for implementing the free basic water policy
Lenehan AM; Abelitis L

This study investigated the cost-recovery efficiency of the trickle feed system. In this system a known quantity of water is delivered each day to a storage tank at each customer's house. This allows the implementation of a monthly prepaid cost-recovery system with relatively low administration. There are potential benefits of implementing the trickle feed system in rural areas and it is currently implemented in pilot projects in Northern KwaZulu-Natal.

Report No: TT 210/03
ISBN: 1 77005 031 0
Overseas price: $10-00 excl postage

The measurement and reduction of urban litter entering storm water drainage systems
Marais M Armitage N

This project addresses the following aims:

- The improvement in the knowledge of the source type and amount of urban litter coming from different types of urban catchments; and
- Provision of scientific data on the efficacy of various management techniques in reducing the amount of urban litter reaching drainage systems. This information, together with the knowledge, would enable the development of Litter Management Plans (LMPs) resulting in reduced litter loadings and realizing considerable cost savings.

Report No: TT 211/03
ISBN: 1 77005 041 8
Overseas price: $30-00 excl postage

Making Water work for villages
Moat C; van den Voorden C; Wilson I

Evaluation studies of new water projects show that poor operation and maintenance (O&M) of water supply schemes is responsible for the high failure rate of water projects. These studies have also shown that the O&M systems that were implemented were generally unresponsive to user needs. This highlights the importance of basing the development of O&M guidelines on local knowledge. This study captured the different methods that communities have used to manage their water supply schemes prior to the implementation of new water projects. The study has also documented local knowledge and experience that has formed the basis for the development of O&M guidelines.

Report No: TT 216/03
ISBN: 1 77005 073 6
Overseas price: $20-00 excl postage

A guidebook on household water supply for rural areas with saline groundwater
Goldie I; Sanderson RD

This report captures and presents options of small-scale water purification technologies for potable water supply to farms, schools, clinics and small communities from brackish surface water sources. The report produced in the form of a guide will assist decision makers in the selection of these technologies. Both membrane-and distillation-based technologies have been assessed, mostly in terms of a desk study. Recently developed local innovations are also included into this guide.

Report No: TT 221/04
ISBN: 1 77005 107 4
Overseas price: $30-00 excl postage

Feasibility of water fluoridation for South Africa
Genthe B; Herold CE Haarhoff J; Hosking S; Syke G

A team, consisting of five experts in their fields, was requested to perform a desk study to identify both the positive and negative consequences which could be expected to arise following the fluoridation of potable water supplies in South Africa.. Results from the study for the first time summarize and bring together a whole spectrum of aspects to take into consideration when potable water supplies are fluoridated. The results show that further actions, including further research, are required before fluoridation can be effected with full safety and confidence in a developing country such as South Africa.

Report No: TT 222/04
ISBN: 1 177005 108 2
Overseas price: $25-00 excl postage

A summary of lessons and experiences from the Ethekwini pilot shallow sewer study
Patti Eslick; John Harrison

Sanitation, because of the major impact it has on health and quality of life, is a service with a high priority. Findings from a previous WRC study indicated that shallow sewer systems provide a viable intermediate sanitation alternative, with a total cost between Ventilated Improved Pit latrines (VIPs) and conventional sewerage. With this as a stimulus, the Durban Metro Water was the first local authority to indicate interest in taking the recommendations further. This study captures the lessons and experiences from the pilot implementation of the shallow sewers.

Report No: TT 225/04
ISBN: 1 77005 135 X
Overseas price: $20-00 excl postage

An introduction to the concepts of customer relations management for water services institutions
Naidoo J; Mosdell T

The fact that the concept of customer service has received little attention in South Africa is perhaps related to the historic situation where water supply and sanitation services were provided on a monopolistic take it or leave it basis, particularly in the case of poorer customers. It is now recognized increasingly that successful water services provision is strongly associated with the application of good business principles. This implies a service orientation, with a primary focus on the customer. This report provides an overview of customer management, principles and methodology.

Report No: TT 227/04
ISBN: 1 77005 147 3
Overseas price:$20-00 excl postage

Community identified performance indicators for measuring water services
Schoeman G; Magongoa

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 228/04
ISBN: 1 77005 158 9
Overseas Price: $15-00 excl postage

Guidelines for economic regulation of water services in South Africa
Palmer Development group

For the regulation of water services to become effective in South Africa, considerable work needs to be undertaken. In particular the methodology to be used in undertaking economic regulation is one of the key components. This report has investigated the subject of economic regulation and its relevance to South Africa and has defined the manner in which water services authorities should regulate water services providers, within the current legislative framework. It highlights the importance of the methodology for economic regulation and in particular regulating tariffs and associated financial parameters. This report is aimed to stimulate discussion on the subject matter, towards effective economic regulation.

Report No: TT 229/04
ISBN: 1 77005 164 3
Overseas price: $20-00 excl postage

Guidelines on reduction of the impact of water infiltration into sewers.
Stephenson D; Barta B

The effects of urban developments on storm water quality and quantity as well as groundwater infiltration into the sewer facilities cannot be left anymore to ad hoc solutions and there is an urgency for a strategic approach to these problems. This report based on identifying and quantifying the problem of ingress, provides the necessary strategy and answers to these problems.

Report No: TT 239/05
ISBN: 1 77005 264 X
Overseas Price: $20-00 excl postage

Benchmarking of leakage from water reticulation systems in South Africa
McKenzie RS; Seago C

In the attempt to get a better handle on the level of leakage at a municipal and national level, this study was undertaken in order to assess the levels of leakage in various water utilities throughout South Africa. The standard water auditing model BENCHLEAK, previously developed through a WRC study was used for the analyses since it is relatively simple to use and follows the standard IWA and BABE leakage benchmarking methodology. Benchleak introduces the concept of Infrastructure Leakage Index (ILI) as a standard method for the purpose of leakage evaluation, as it has been found to bet the most reliable and meaningful indicator.

Report No: TT 244/05
ISBN: 1 77005 282 8
Overseas Price: $25-00 excl postage

Water and waste-water management in the power generating industry (NATSURV 16)
Van Zyl HD; Premlall K

The power-generating industry in the RSA is a substantial water user and effluent producer and impacts nationally both on water use allocations and the maintenance of resource water quality. The report provides the volumes and breakdown of water taken in and discharged by major and minor power generating plants, to determine pollutant loads and identify suitable wastewater management processes and strategies, and to a guideline document assisting both the industry and regulators in effective water and wastewater management of this sector.

Report No: TT 240/05
ISBN: 1 77005 270 4
Overseas Price: $15-00 excl postage

Ecological sanitation - Literature review
Austin LM; Duncker LC; Marsebe; Phasha MC; Cloete TE

Urine-diversion sanitation systems have been successfully implemented in many countries; including South Africa where about 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. This report captures the state of knowledge on urine diversion toilets.

Report No: TT 246/05
ISBN: 1 77005 322 0
Overseas price: $25-00 excl postage

Guidelines for ensuring sustainable effective disinfection in small water supply systems.
Momba MNB; Brouckaert BM

This is a follow-up to a previous project that evaluated a combined chlorine-monochloramine disinfection process for the inhibition of bacterial and bio film re growth in a laboratory-scale system. The emphasis is based on the maintenance of an effective residual disinfectant throughout the water system. This report provides strategies which will ensure sustainable effective disinfection in small municipal water distribution systems.

Report No: TT 249/05
ISBN: 1 77005 321 2
Overseas price: $30-00 excl postage

Water poverty mapping: Development and introduction using a case study at the local municipal scale for the Eastern Cape.
Cullis J

This report demonstrates the feasibility of using water poverty mapping to define and study the nature of water poverty in South Africa as well as the basis for a clear decision tool for the allocation of scarce resources to development initiatives that will be most effective and as a way of measuring the impact of these initiatives.

Report No: TT 250/05
ISBN: 1 77005 337 9
Overseas price: $20-00 excl postage

Handbook for Waterworks Operation
Christiaan Frederick Schutte (Editor)

There are a number of different books and instruction guides (mostly sourced from abroad and excessively priced in South African terms) available to assist with training of water treatment works operators, but a survey of these showed that none of the existing books is suitable to be used as a basis book for reference and for training. This report is an excellent reference book for training of water plant operators, as well as for the operation of water treatment works.

Report No: TT 265/06
ISBN: 1 77005 428 6
Overseas price: $25-00 excl postage

The development of a successful unaccounted-for water management programme in the rural water supply context.
Ross-Jordan J

The challenge to develop simple and effective systems that are easily understood by water committees has resulted in this report which can be used by the community as well as their local authority to manage water losses in distribution systems.

Report No: TT 256/06
ISBN: 1 77005 392 1
Overseas price: $20-00 excl postage

The use of key performance indicators in the benchmarking of rural water supply schemes: An aid to development of meaningful local government capacity.
Still D; Balfour F

New local authorities have limited knowledge on the nature of inspection needed to promote good management at community level. Therefore, the challenge was to develop simple and effective systems that are easily understood by water committees. These can be used to report to the community as well as to their local authority. This report provides a set of key performance indicators (KPIs) which have been tested on a number of RDP projects that are presently being transferred from Umgeni Water to relevant district councils in KwaZulu-Natal.

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The WRC community based health and hygiene model and implementation kit
Bolu O; Maliti N

This research seeks to support the acceleration of sanitation service delivery without improving developmental principles such as demonstration of ownership and community based participation. The study will investigate methods of improving communities so that they can earn an income which will enable them to make a partial contribution to the costs of building toilets. The study will be undertaken in selected villages in the Eastern Cape.

Report No: TT 264/06
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Overseas price: $20-00 excl postage

A strategic framework for water-related human health research.
Venter SN; Mjoli NP

The report is a compilation of a framework and strategy plan to guide the future funding of priority research on the improvement of water related human health in Southern Africa. The plan had to include health related aspects of all human-water interactions. The plan further identifies research gaps for future, local, research on water related human health and a list of institutions and researchers active in health research, both nationally and internationally.

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1. **Waste Minimisation Clubs in SA (Facilitator's Manual)**
2. **Waste Minimisation Clubs in SA (Training Manual)**

Barclay S; Buckley C

Previous WRC Project No. 973 detailed the feasibility of waste minimisation (WasteMin) clubs as a model for achieving significant improvements in environmental performance by local industry. The aim of this follow-up project No. 1171 was to develop a methodology for promoting, managing and sustaining waste minimisation clubs, by producing inter alia guides for effectively establishing and managing WasteMin clubs, specific sectoral self-assessment guides, and training material for WasteMin consultants in a franchised operation. The project's two technology transfer products are a Facilitator's Manual and a Training Manual. The Facilitator's Manual is aimed at a person or organisation that wishes to initiate a waste minimisation club and requires guidelines for undertaking such a project. It addresses aspects such as how to form a club, call meetings, determine the level of contributions from companies, identify some of the problems that can occur, and explains the various roles of the people involved. It also provides sample letters and presentations, and provides sources of information. The Facilitator's Manual draws on the experiences gained in the previous WRC project no. 973 and also that gained from facilitators of other waste minimisation clubs in South Africa, facilitated by various organisations such as consultants, University researchers and, in at least one case, by the company itself as an in-house club.

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Report No: TT 284/07
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Life cycle costing analyses for pipeline design and supporting software.
van Vuuren SJ; van Dijk M

There are various factors that influence the hydraulic capacity and pipeline designers need to take all of these into consideration during the design. For instance the estimation of roughness parameter for a pipeline has a significant effect on the hydraulic capacity and operational costs. An underestimation of this parameter can be catastrophic when the required demand cannot be met. Findings identified that the two main contributing factors of energy losses are:

- Inherent resistance against flow exerted by the fluid (i.e. viscosity) and
- The friction losses resulting from the interface between the fluid and the conduit boundary (i.e. shear), as well as secondary losses resulting from abrupt local changes in the system.
- The roughness parameters that are normally quoted by manufacturers tend to be to low.

Report No: TT 278/07
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Overseas price: $20-00 excl postage

A research strategy for the detection and management of algal toxins in water sources.
Harding WR

This analysis undertaken in support of the development of a cyanobacterial and cyanobacterial toxin research strategy in South African water sources has identified two vital planning elements, viz.

- The need to create a management and support infrastructure and
- The research aspects best suited to South African cyanobacterial research needs.

In addition, there is a clear indication that successes will be limited should collaboration with overseas specialists and organizations not be implemented. To South Africa's advantage is its current involvement in both the Global Water Research Coalition (GWRC) and CYANONET initiatives, plus willingness expressed by international specialists formerly associated with cyanobacterial work in South Africa to continue their association. Allied to this is the cosmopolitan nature of the cyanobacterial problems as experienced worldwide. This analysis was fortunate to have been commissioned during the year (2004) that saw the launch of the GWRC and CYANONET initiatives, as well as two key international conferences that allowed for the identification of globally-relevant research initiatives and emerging issues.

The strategy proposed here is based on comparing and contrasting the current directions and emerging issues in international cyanobacterial research with identified South African needs. From this analysis a suite of key research issues have been formulated.

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Guidelines for the design, operation and maintenance of urine-diversion sanitation systems
Austen LM

If a dry toilet (i.e. not requiring water for its operation) is designed and constructed in such a way that the

faeces vault can be quickly, easily and safely emptied, then one of the biggest maintenance problems will be obviated. If the processed excreta can also be productively and safely used for agriculture, the technology will become even more attractive. In South Africa, where many rural communities rely on subsistence agriculture, often in poor soils, and with urban agriculture becoming more common, this is an important aspect. Urine-diversion sanitation systems address the above opportunities. They have been successfully implemented in many countries, including South Africa where more than 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. A need has thus been identified to create further competence in this area of sanitation in South Africa, and to increase knowledge concerning the technology. The technology is increasingly being introduced in a manner which consists of faulty design, poor implementation and improper use. This study developed strategies and guidelines, through monitoring and evaluating existing schemes, which would provide fundamental answers in the sustainable management of this technology.

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Overseas price: $15-00 excl postage

A desalination guide for South African municipal engineers.
du Plessis JA; Burger AJ: Swartz CD; Musee N

Municipalities have to develop Water Service Development Plans (WSDP's) as part of Integrated Development Plans (IDP's) as a first requirement in their budgetary process, and have to be aware of what options are available to provide adequate water services. While 25_/person/day has been set as the minimum basic water supply and while many consumers receive far in excess of this amount, there are areas of the country where enough fresh water of acceptable quality is not available for household use. However, in many areas adequate quantities of saline water may be or are readily available. This is especially the case for coastal cities and towns. The cost of treating water is a fraction of the total cost of making water available to the consumer. This, together with the fact that membrane desalination technology is becoming more affordable, makes the overall water tariff less dependent on the cost of desalination. In other words, desalination may in many cases become a viable option to supply fresh water for domestic purposes. Therefore, DWAF identified a need to provide guidelines and procedures to select and evaluate suitable treatment options for desalinating sea water from both the Indian and Atlantic oceans, or brackish water from boreholes.

The specific objectives of the project were to identify the technologies which may currently be commercially implemented in South Africa to treat saline water to drinking water standards, to identify typical pre-treatment requirements, and to identify the most common technical, operating and environmental problems experienced in the selection and use of these technologies. An important aspect was also to provide estimates for capital and operating costs, as would be required to successfully bring the water to the accepted standards for potable and domestic use. Of particular importance for the South African application was to identify the level of skills required for daily operation of the desalination plants, the level of skills required to provide technical back-up and advice, and to identify and advise on the competencies, training needs and capacity building required at operator and management levels. Lastly, the relevant local environmental legislations governing desalination were also identified.

Report No: TT 266/06
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Overseas price: $30-00 excl postage

Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers
Du Preez H; van Baalen

An increase in the eutrophication of surface water resources is leading to increased incidence of toxic blue-green algae growth – thereby increasing health risks when drinking water from a treatment plant which does not use activated carbon adsorption in its process train. No structured framework yet exists in South Africa to manage the supply of safe drinking water during a persistent blue-green algae bloom in the source water. The project aims to establish such a pro-active approach by means of a generic algal bloom incident management framework to effectively manage potable water supply when toxic algal blooms are present. Such a system will be widely applicable to water services providers and will reduce the risk of human incidents related to blue green algae toxins by providing this framework for informed and appropriate pro-active management measures.

Report No: TT 263/06
ISBN: 1 77005 472 3
Overseas price: $25-00 excl postage

An assessment of non-revenue water in South Africa.
Seago CJ; McKenzie RS;

Municipal water use in South Africa has been under investigation for many years and the Department of Water Affairs and Forestry has been trying to establish the levels of wastage from all water supply systems countrywide. This has proved a very difficult task due to the absence of reliable data in many Municipalities as well as confusion regarding how such wastage should be estimated. Until the wastage can be quantified accurately, it is impossible to develop and prioritise the actions that must be taken to ensure that water is used effectively and efficiently in this water scarce country. Despite many problems associated with the gathering of data from the various water utilities, the study was able to obtain information from 62 of the largest water reticulation systems throughout South Africa. It was found that the average bulk system input volume per property served for the 19 low income areas analysed as part of the study was approximately 37 k_ per property per month. The losses (real and apparent) for the 62 systems analysed was estimated to be 623 million m3/annum or 29% of the total water supplied.

Report No: TT 300/07
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Overseas price: $20-00 excl postage

KSA 4

On-farm application of in-field rainwater harvesting techniques on small plots in the central region of South Africa: Vol 1 – Main Report
Botha JJ; Anderson JJ; Nhlabatsi NN

Water harvesting is the process of concentrating rainfall as runoff from a larger area for its productive use on a smaller area. A number of Water Research Commission projects on the In-field rainwater harvesting (IRWH) technique have demonstrated that rural communities can greatly benefit from this production practice. Intensive field experiments on clay and duplex soils, conducted over a period of six seasons, indicated that IRWH increased maize and sunflower yields by as much as 50%, compared to conventional production techniques (CON). Research results over a number of years have indicated that the IRWH technique is sustainable in terms of increased agronomic productivity, reduction of risk, conservation of the natural resources base, social acceptability and economic feasibility. This technology transfer project was initially planned for implementation in six rural communities around the towns of Thaba Nchu and Botshabelo in the Free State province

The technology exchange process expanded rapidly resulting in many more households and communities than initially anticipated implementing the IRWH technique that the need arose to employ a proper exit strategy that ensured continued implementation of the technique by interested communities. As the number of farmers and communities using IRWH techniques increased, a decision was taken by representatives from each group and community to form a municipal-based water harvesting interest group (MB:WHIG). This body was later named the Tswelelopele Small Farmers Cooperative (TSFC). Amongst the organisations that were co-opted into the structure were the municipality, the tribal authority and the local agriculture office.

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Overseas price: $20-00excl postage

The social/cultural acceptability of using human excreta (Faeces and Urine) for food production in rural settlements in South Africa
Duncker LC; Matsebe GM; Moilwa N

Introducing and operating sanitation systems that promote the use of human excreta in rural areas require a combination of technical and managerial aspects that fit the prevailing socio-cultural context in the specific area. An in-depth understanding of the social and mental fabric concerning people's views towards recirculation of nutrients is necessary in order to understand the motivational factors behind people's acceptance or rejection of using human excreta for food production. No research has been conducted so far in this field of study in South Africa, and therefore the scoping study is required to investigate the status quo, determine the views and attitudes of people towards the use of human excreta in food production, and to guide relevant future interventions and actions regarding use of human excreta. Use of human excreta for agricultural purposes may not only have direct benefits of protecting and improving natural resources such as water and soils and enable households to increase food crops, but also indirect benefits of improved food security resulting in improved health of the individual, greater productivity, increased economic output and opportunities, and a decreasing burden on social services.

Report No: TT 310/07
ISBN: 978 1 77005 592 6
Overseas price: $25-00 excl postage

A Procedure for an improved soil survey technique for delineating land suitable for rainwater harvesting.
Hensley M; Roux PAL; Gutter J; Zerizghy MG

Subsistence farmers in rural semi-arid areas with low cropping potential are a category of poor people in South Africa that the Government urgently wants to assist. Their well-being is jeopardized by a low income and inadequate food security. To address this problem a number of research projects, managed and funded by the Water Research Commission (WRC), have been launched during the last ten years by the ARC-Institute for Soil Climate and Water (ISCW) located at Glen. Success in this regard was achieved, shown by the fact that large numbers of households in the region now successfully use IRWH to grow maize and vegetables in their backyards. The time is now ripe for expanding the application of IRWH to the relatively large unused cropland areas available to these subsistence farmers. The need then arises to identify and delineate the portion of each village area that is suitable for IRWH. Because of the relatively small area of cropland allocated to each household it is essential that the soil survey be conducted on an intensive basis, at a scale of at least 1: 10 000, but preferably larger. Intensive soil surveys at this scale, carried out using the traditional grid technique, are costly. It was hypothesised that it should be possible to develop a more effective survey procedure to select suitable land for IRWH by maximising the application of tacit knowledge and employing modern and innovative technology. Aware of this need the WRC has wisely created this research project to test this hypothesis.

Report No: TT 311/07
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Overseas price: $20-00 excl postage

A Manual for cost benefit analysis in SA with specific reference to water resource development: Second Edition (Updated and Revised)
Mullins D; Mosaka DD; Green AB; Downing R; Mapekula PG

This guideline is in the format of a manual for conducting Cost-Benefit Analysis (CBA) in South Africa with specific reference to evaluating the development and management of water resources. This evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. The CBA method, provides a logical framework by means of which projects can be evaluated, serving as an aid in the decision making process. This manual is specifically aimed at the decision maker in the public sector, but can also be used outside the public sector.

It is interesting to note a few highlights of the CBA Manual. A broader approach is followed to incorporate the relationships between CBA and other aspects of the economy. In this regard the following aspects have been included:

- the relationship between the principles of CBA and welfare economics;
- CBA as one component of the range of decision making support instruments;
- The equity and efficiency principles;

Thus it deals specifically with the uses, limitations and basic principles of CBA in order to explain the underlying conceptual framework to the reader. This manual advocates that the CBA concept needs to be widened to include the broader social costs and benefits derived from a project. Furthermore it is also accepted that CBA is only one of several instruments for evaluating proposed projects. One of the main objectives therefore was to incorporate an income weighting system. This system provides for the recognition of some of the macroeconomic policies of the government e.g. combating poverty and promoting regional development.

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Overseas price: $30-00 excl postage

Technology transfer for implementation of the FARMS system
Botha PW; Oosthuizen LK; Meiring JA

Over the last 10 years, three WRC funded research projects were undertaken to develop user-friendly models to provide decision-support for farmers. The aims of this technology transfer project were firstly, to train agribusinesses, bureau services and advisors in the main irrigation areas of South Africa to implement the Risk Man (Risk Management), IrriCost (Irrigation Cost Estimator) and FARMS (Firm Level Agricultural Management Simulator) computer software for decision-taking support in the field of risk management, irrigation cost estimation and whole farm planning respectively; and secondly, to give these organisations and individuals the necessary support in order for them to apply the abovementioned computer software on a continuous basis.

New technology must pass through several stages before it is accepted. The five stages of adoption are awareness, interest, evaluation, trial and

adoption. The implementation strategy with this technology transfer project consisted of a combination of methods, messages and approaches followed by the research team. The first step was to identify target groups to whom the three programs were demonstrated. The demonstrations were attended by the contact person of that area together with potential adopters of the technology. These demonstrations were used to create awareness and interest in the use of the models. The next step was to arrange workshops for interested persons for specific models to make further progress with the technology adoption process. The website was used to provide additional information about forthcoming courses and continuous support on larger scale adoption and application.

Report No: TT 274/05
ISBN: 1 77005 450 2
Overseas price: $20-00 excl postage

Building capacity in irrigation management with wetting front detectors
R Stirzaker; CSIRO; Stevens J; Annandale J; Maeko T; Steyn M; Mpandeli S ;Maurobane W; Nkgapele J; Jovanovic N

Scheduling of irrigation does not only ensure that adequate volumes of water are applied. It also ensures that many people who rely on the limited water resource can share. Much as irrigators are aware of the importance of scheduling, very few practice it. A wide range of reasons for not scheduling exists, the common ones being the high level of management required and the costs involved. With simple and cheap scheduling tools, water savings will be achieved and farmers will soon realise the importance of irrigation scheduling and its benefits. The project is aimed at improving adoption of irrigation scheduling through the introduction of a cheap and simple technique. It also evaluates factors affecting the acceptability of this irrigation scheduling technology by resource-poor and commercial farmers.

Report No: TT 230/04
ISBN: 1 77005 138 4
Overseas price: $25-00 excl postage

Using Sapwat to estimate water requirements of crops in selected irrigation areas managed by the Orange - Vaal and Orange – Riet water users association
Van Heerden PS, Crosby CT & Crosby CP

This report serves as a user manual for the application of SAPWAT. Furthermore, it demonstrates that the estimation of irrigation requirements can be credible and that the requirements that the National Water Act (36 of 1998) sets for future water management can be met.

Report No: TT 163/01
ISBN: 1 86845 812 1
Overseas price: $30-00 excl postage

Micro-irrigation for smallholders: Guidelines for funders, planners, designers and support staff in SA
Du Plessis FJ; Van Averbeke W; Van der Stoep I

The objective of this project was to assess how small-scale farmers experience the concept of micro-irrigation systems and how they cope with problems. The aim was to identify those aspects that eventually determine the success or failure of small-scale crop production, utilising these systems. During the course of the project it became apparent that external factors, generic to any small-scale farming system and seemingly unrelated to micro-irrigation, had a significant influence, and that it would, therefore, be almost impossible to evaluate the former without taking the latter into account. The aim of the guideline report is to help prevent mistakes of the past and, hopefully, it will contribute to policy-making on a small scale regarding the utilisation of micro-irrigation. Thus, the successful use of the systems is ensured.

Report No: TT 164/01
ISBN: 1 86845 824 5
Overseas price: $15-00 excl postage

Contribution of aquaculture to rural livelihoods in South Africa: A baseline study
Rouhani QA; Britz PJ

At present there is a lack of information on the importance of fish production systems in agricultural activities, the contribution it makes to household food security and constraints or opportunities which exist for expansion. This study should highlight specific topics for research projects that need attention. Particular emphasis will be placed on research of water-related issues that will lead to an improvement of rural livelihoods.

Report No: TT 235/05
ISBN: 1 77005 186 4
Overseas price: $25-00 excl postage

Guidelines for irrigation water measurement in practice.
Vd Stoep I; Benade N; Smal HS; Reinders FB

Effective management of water resources can be vastly improved if water use is measured accurately. This applies in particular to efforts to influence the quantity of water demanded by levying tariffs on the volume of water actually consumed. However, on most irrigation schemes water flow is not measured and water tariffs are presently still levied on an area and not a volumetric basis. This report is as a result of a comprehensive study of water measurement in irrigation.

Report No: TT 248/05
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Overseas price: $25-00 excl postage

Irrigation scheduling using the Soil Water Balance (SWB) model as a user-friendly irrigation scheduling tool.
Annandale JG; Steyn JM; Benade N; Jovanovic NZ; Soundy P

Most commercial farmers recognise that effective irrigation scheduling is a prerequisite to save on irrigation water and to improve on water-use efficiency. However, only a small percentage of irrigation farmers currently uses any scientific irrigation scheduling aid. One important reason may have been the lack of quick, simple and reliable irrigation scheduling techniques. This aspect has been addressed to a large extent by the development of the SWB model. Although the model follows a scientifically based mechanistic approach, a user-friendly interface makes it accessible to any person with basic computer training.
Report No: TT 251/05
ISBN: 1 77005 339 5
Overseas price: $20-00 excl postage

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: A rough guide for irrigation development practitioners: Vol 1
Denison J; Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.
The 'Rough Guide' (Volume 1) is a quick reference guide that covers policy implications and revitalisation objectives, as well as recommended principles, approaches and methodologies for

scheme diagnosis, participative planning, feasibility evaluation and formulation of farmer support programmes.

Report No: TT 308/07
ISBN: 978 1 77005 568 1
Overseas price: $25-00 excl postage

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: Concepts and cases: Vol 2
Denison J; Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.

'Concepts and Cases' (Volume 2) contains the theoretical rationale for the guidelines. Four major South African revitalisation initiatives are compared with international initiatives and success factors are identified. Eight farmer support approaches are documented, providing lessons of best practice as well as alternatives for programme design, and new approaches are presented. These are a tailored consultative planning approach, a land-leasing strategy for irrigation schemes and the formulation of four basic farming styles to guide planning.

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