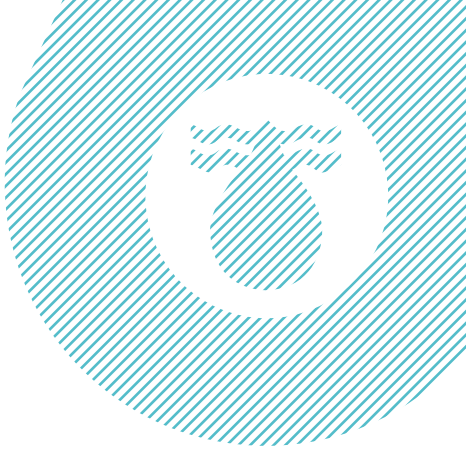
WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW 2012 | 2013



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INTRODUCTION

DHESIGEN NAIDOO | CEO

INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2012/13, the WRC fulfilled its mandate to contribute positively to South Africa's ability to address its water challenges through research and development solutions. The WRC supported the sector with research products aimed at informed decision-making, improving monitoring and assessment tools, and making available a range of new and improved technologies related to water resource management, improved use of water in agriculture and the provision of water and sanitation services. The research portfolio for 2012/13 was set on the basis of the WRC's Corporate Plan.

The WRC continued to invest in the creation of knowledge via its four main key strategic areas (KSAs): **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management, and Water Utilisation in Agriculture** (Fig. 1). A further development in 2012/13 was the reorientation of **KSA 5: Business Development, Marketing and Communications** to provide strategic direction to the business development, communication, marketing and branding goals of the WRC, with an emphasis on research uptake and knowledge dissemination.

WATER RESOURCE MANAGEMENT

- Water resource assessment and planning
- Water quality management
- Water resource protection
- Water resources and climate
- Water resource institutional arrangements

WATER-LINKED ECOSYSTEMS

- Ecosystem processes
- Ecosystem management and utilisation
- Ecosystem rehabilitation

WATER USE AND WASTE MANAGEMENT

- Water services - Institutional and management issues
- Water supply and treatment technology
- Sustainable municipal wastewater and sanitation
- Sustainable and integrated industrial water management
- Mine-water treatment and management
- WaterSmart Fund

WATER UTILISATION IN AGRICULTURE

- Water utilisation for food and fibre production
- Water utilisation for fuelwood and timber production
- Water utilisation for poverty reduction and wealth creation in agriculture
- Water resource protection and reclamation in agriculture

Figure 1. Key strategic research areas and thrusts

Contributing towards achieving Government Outcomes

As a national public agency, the WRC actively strives to support the Government of South Africa in achieving its strategic outcomes, with particular reference to the Corporate Plan (Annual Performance Plan) of the Department of Water Affairs (DWA) and the performance agreement of the Minister of Water and Environmental Affairs. Of particular relevance to the work of the Commission is Government Outcome 10, as well as Outcomes 6, 7, and 9:

- Outcome 6 – the WRC actively strives to align its projects and activities with achieving an efficient, competitive and responsive economic infrastructure network.
- Outcome 7 – the WRC actively strives to align its projects and activities with achieving vibrant, equitable and sustainable rural communities and food security for all.
- Outcome 9 – the WRC actively strives to align its projects and activities with achieving a responsive, accountable, effective and efficient local government system.
- Outcome 10 – the WRC actively strives to align its projects and activities with achieving protection and enhancement of the country's environmental assets and natural resources.

Achieving the goals of the WRC Knowledge Tree

A fundamental guiding framework and corporate planning tool for the WRC's operations at the beginning of its fifth decade is the construct of the WRC Knowledge Tree (Fig. 2). The tree metaphor reflects strength in foundation (i.e., 'roots' firmly embedded in sound knowledge) and strong growth (i.e., 'branches and leaves' growing vigorously from this knowledge). It also acts as a yardstick with which to measure the WRC's impact in key domains.

Figure 2. The WRC Knowledge Tree

Each of the Knowledge Tree strategic outcome-oriented goals provides a specific priority categorisation for the WRC's projects and activities. Each has its own kind of contribution to the Government Outcomes, either directly or indirectly. The goals are not mutually exclusive. For example, a 'new product' may be a 'sustainable development solution' that 'empowers communities' and 'informs policy and decision making'.

The guiding principle is that every WRC project will strive to achieve as many of the WRC Knowledge Tree outcomes as reasonably possible. This applies within the project, to post-project actions, and to follow-on projects.

Supporting research projects

In 2012/13 the WRC managed 305 research projects at various stages of the project lifecycle (Table 1) of which 79% (242 projects) were active projects.

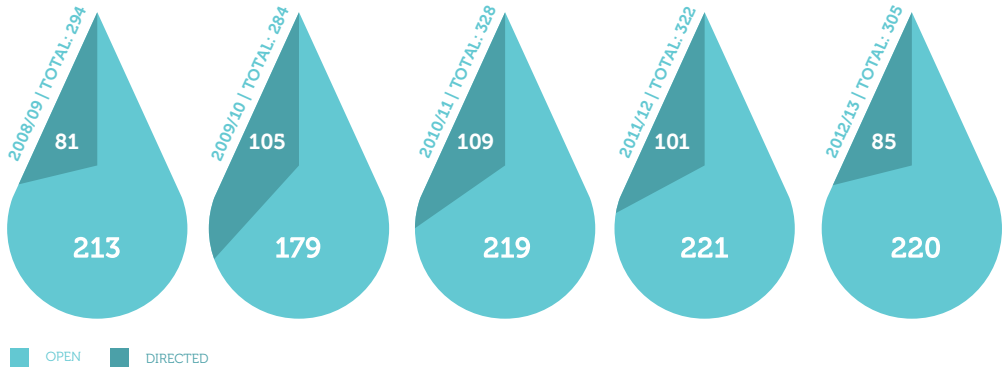
The remainder mostly comprised of projects that have been finalised and are in the process of being financially closed. A total of 85 projects were completed during 2012/13, distributed across Water Resource Management (KSA 1: 21 projects), Water-Linked Ecosystems (KSA 2: 18 projects), Water Use and Waste Management (KSA 3: 37 projects), and Water Utilisation in Agriculture (KSA 4: 9 projects). The WRC also initiated 81 new projects: 28 focusing on Water Resource Management (KSA 1), 13 on Water-Linked Ecosystems (KSA 2), 32 on Water Use and Waste Management (KSA 3) and 8 on Water Utilisation in Agriculture (KSA 4). The WRC published 151 research reports in this period as well as 3 DVDs. The various funding streams included both open projects, accommodating projects within the broad research strategy of each key strategic area, and directed projects, where research projects are developed in accordance with clear terms of reference, aimed at solving specific problems. Open research projects are mostly long-term, consortia-based, and address multifaceted issues, often calling for more than one research discipline and a substantial budget. About 28% of the total number of projects were directed projects.

Table 1. Overview of research project activity for the year under review

Financial year	2012/13	2011/12
Total number of projects	305	322
Number of active projects	242	258
Number of new projects	81	74
Number of finalised projects	85	96
Number of directed projects	85	101

Figure 3 provides a schematic representation of the total number of research projects per annum for the past five years. The average number of projects per year remains around 300.

Figure 3. Total number of open and directed research projects per annum for the past five years



Over the past 5 years the WRC has finalised 378 research projects (Fig. 4) indicating a significant contribution to knowledge in the water sector. An average number of 76 projects were finalised per year, for the past 5 years. Over the same 5-year period 356 new projects (Fig. 5) were initiated, ensuring the continuous contribution of new knowledge to the sector. An average of 71 new projects were started per year, for the past 5 years.

Figure 4. Annual and cumulative number of projects finalised over the past five years

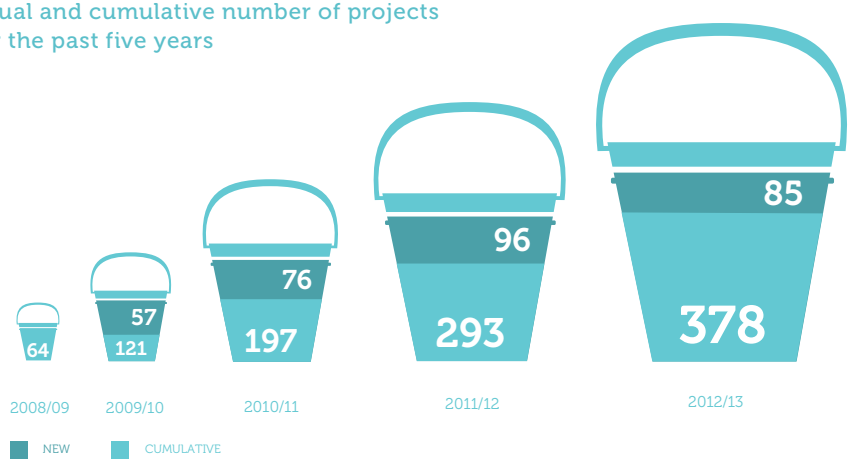


Figure 5. Annual and cumulative number of projects initiated over the past five years

The percentage utilisation of research project funds by the KSAs during 2012/13 (Fig. 6) indicates that approximately 48% (in comparison with about 45% for 2011/12) was invested in projects that focused on water resources (including water-linked ecosystems) and approximately 52% (compared with 55% for 2011/12) in projects that focused on water utilisation (including effluent treatment and management, as well as agriculture). This is based on the actual amount paid out as well as accrued for research projects during the financial year under review. The allocation of about 50% of the fund to issues related to resource management and 50% to issues related to water utilisation was a strategic allocation based on the medium- to long-term needs for research. The percentage of funds utilised for the different KSAs in shown in Fig. 6.

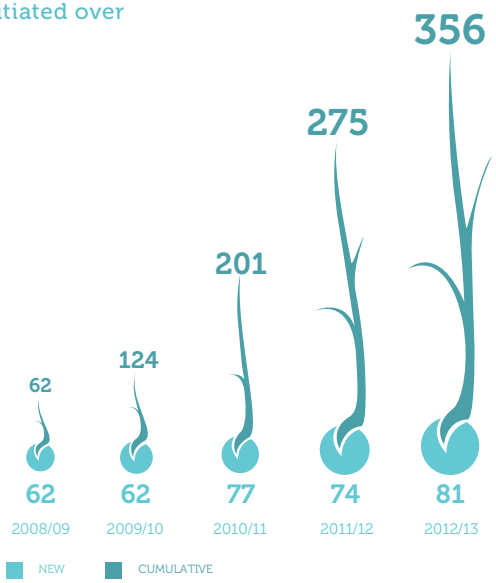
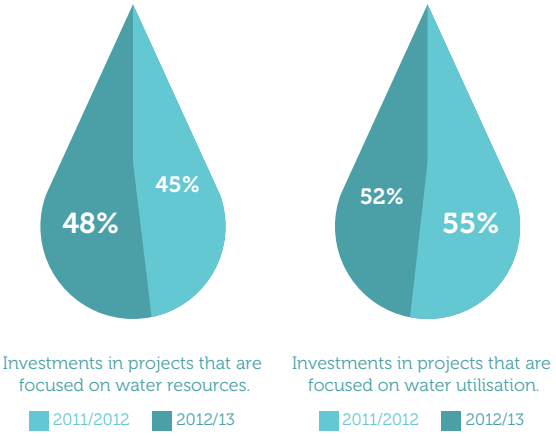


Figure 6. Percentage of funds utilised for the different KSAs in 2012/13

The overall investment in research projects (knowledge creation) amounted to R116.7 m. This was marginally more than that reported for 2011/12 (R110.5 m.), with an increase of 6%. Total investment in the support of knowledge creation, sharing and dissemination amounted to R144.7 m. This represents an increase of 3% from the previous year (R140.9 m.).



Leveraging income for the creation, sharing and dissemination of water 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 2012/13 this drive was fairly successful, but substantial amounts have been rolled over into 2013/14, e.g., the upfront funding received from the Melinda and Bill Gates Foundation. The WRC income originating from sources other than the levy for 2012/13 amounted to R19.6 m. Leveraged income included funds allocated to a number of KSAs for direct support of research projects and funds provided for capacity building, knowledge sharing and dissemination. 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 for other knowledge-sharing projects. Sources of income other than the levy for 2012/13 amounted to about 13% of the total income.

BUILDING CAPACITY

The WRC aims to provide South Africa with future researchers as well as a source of skilled human capital for other institutions within the water sector. This is done by encouraging project leaders to include students on their projects, enabling them to participate in water research through the various projects supported by the WRC.

During the year under review, the WRC continued to place strong emphasis on building research capacity in South Africa as well as supporting a number of related capacity-building initiatives. In many areas of research supported by the WRC, it is evident that students who participated in earlier WRC projects are now leading Commission-funded research projects and/or are serving as members of steering committees as well as representatives of new proposals.

Capacity building trends

During the year under review, the WRC gathered more comprehensive demographic data for the students working on WRC-funded projects. Of the 494 students supported by WRC-funded projects in 2012/13, 207 or 42% were female, which is encouraging as most WRC projects fall within the engineering or science category of research where the involvement of females in general remains low. The large number of masters (201 students) and doctoral (142 students) candidates provides a critical mass for the next generation of academics and researchers in the water sector. The wide range of bachelor degrees supported also reflects the WRC's commitment to support a diverse range of disciplines to address water resource challenges in a holistic manner. It is encouraging to note the support provided to a mixture of natural, technical and social science degrees.

Table 2 reflects the number of previously-disadvantaged students involved in WRC-funded projects, as reported for the various lead organisations contracted by the WRC, in the 2012/13 financial year.

Table 2. Number of previously-disadvantaged students (PDI) involved in WRC-funded projects per lead organisation in 2012/13

Institution name	Total PDI
Higher-education institutions	
Cape Peninsula University of Technology	4
Durban University of Technology	7
Nelson Mandela Metropolitan University	5
North-West University	6
Rhodes University	21
Tshwane University of Technology	7
University of Cape Town	13
University of Fort Hare	15
University of Johannesburg	9
University of KwaZulu-Natal	36
University of Pretoria	25
University of South Africa	5
University of Stellenbosch	9
University of the Free State	4
University of the Western Cape	17
University of Venda	4
University of the Witwatersrand	2
Subtotal	**189**

Table 2. Number of previously-disadvantaged students (PDI) involved in WRC-funded projects per lead organisation in 2012/13 (continued)

Science councils and state agencies	
Agricultural Research Council	6
Council for Geoscience	3
CSIR	16
National Institute of Occupational Health	1
South African National Parks	5
South African Weather Service	2
Subtotal	33
Non-governmental institutions	
Counterpoint Development	1
Dames	6
Duncan Hay and Associates	4
Eon Consulting	1
Freshwater Research Centre	1
Golder Associates Africa	5

Table 2. Number of previously-disadvantaged students (PDI) involved in WRC-funded projects per lead organisation in 2012/13 (continued)

Hlathi Development Services	1
Hydrosoft Institute	2
Institute of Natural Resources	2
Kaleo Consulting	1
Metago Water Geosciences (Pty) Ltd	1
Muondli Consulting and Projects	1
Pegasys Strategy and Development (Pty) Ltd	1
Pegram and Associates (Pty) Ltd	3
Prime Africa Consultants (previously CIC International)	1
Southern Waters Ecological Research and Consulting	1
SSI	4
Umhlaba Consulting Group	5
Virtual Consulting	3
WRP Consulting Engineers (Pty) Ltd	1
Subtotal	45
Total	**267**

Other capacity building initiatives

In addition to its support for the training of students, the WRC has initiated and supported a number of national capacity building initiatives. Examples of such initiatives are given below:

Exposing girl learners to water science

The WRC 'adopted' four girl learners during the year as part of Government's Techno Girls initiative. The initiative identifies high-achieving 15- to 18-year-old school girls from previously disadvantaged communities and places them in corporate mentorship and skills development programmes.

Supporting young professional involvement in water law

The role and importance of water law expertise for effective water governance is well recognised in the South African water sector. The governing of how water is used, who uses it and how much is used is consequently very complex and is the substance of a substantial body of law at local, national and international levels. It is therefore critically important that countries encourage the development of water law expertise amongst water professionals in order to draft sound and implementable legal frameworks. In collaboration with the International Water Association (IWA) / Water Institute of Southern Africa (WISA) Young Water Professionals (YWPs), and kindly sponsored by the DWA, the International Conference on Freshwater Governance for Sustainable Development, held in the Drakensburg from 4–7 November 2012, provided the opportunity for students of law to engage in public debates on a range of pertinent issues affecting the South African water sector and also addressed in conference sessions. The YWP debates were listed as one of the highlights of the conference.

WRC 101 for project leaders and research and finance offices

Over the past few years, the WRC has noted an encouraging trend of proposals being submitted by research groups who have previously not applied to the WRC for funding. Many established research groups also have new project leaders managing WRC projects. The WRC, like any other research funding organisation, has project management and administrative requirements, which are reviewed periodically. The more established project leaders will also have noted that the proposal submission, project management, intellectual property management and financial requirements have changed as the different modules of the WRC Fund Management System (FMS) have been completed. Additionally, the WRC has sought to improve its interaction and coordination with current and prospective project teams, in order to streamline administrative processes and to render to the research community a better understanding of the WRC's strategic objectives as defined in its five-year Strategic Plan. This involves informing institutions of the WRC's focus areas and direction for the prioritisation of funds in the next financial year, and encouraging WRC staff members to gain a better understanding of how various institutions operate. In this regard, the WRC conducted the increasingly popular one-day WRC 101 Course for aspiring and new project leaders to:

- Understand the WRC research cycle
- Discover the research priorities of the WRC and the fund allocation for each of the priorities
- Prepare a comprehensive proposal (taking note of tips provided to improve the chances of success)

- Manage the technical, administrative and financial aspects of a WRC project
- Understand the contractual and financial audit requirements
- Know what resources are available to enhance the success of the project

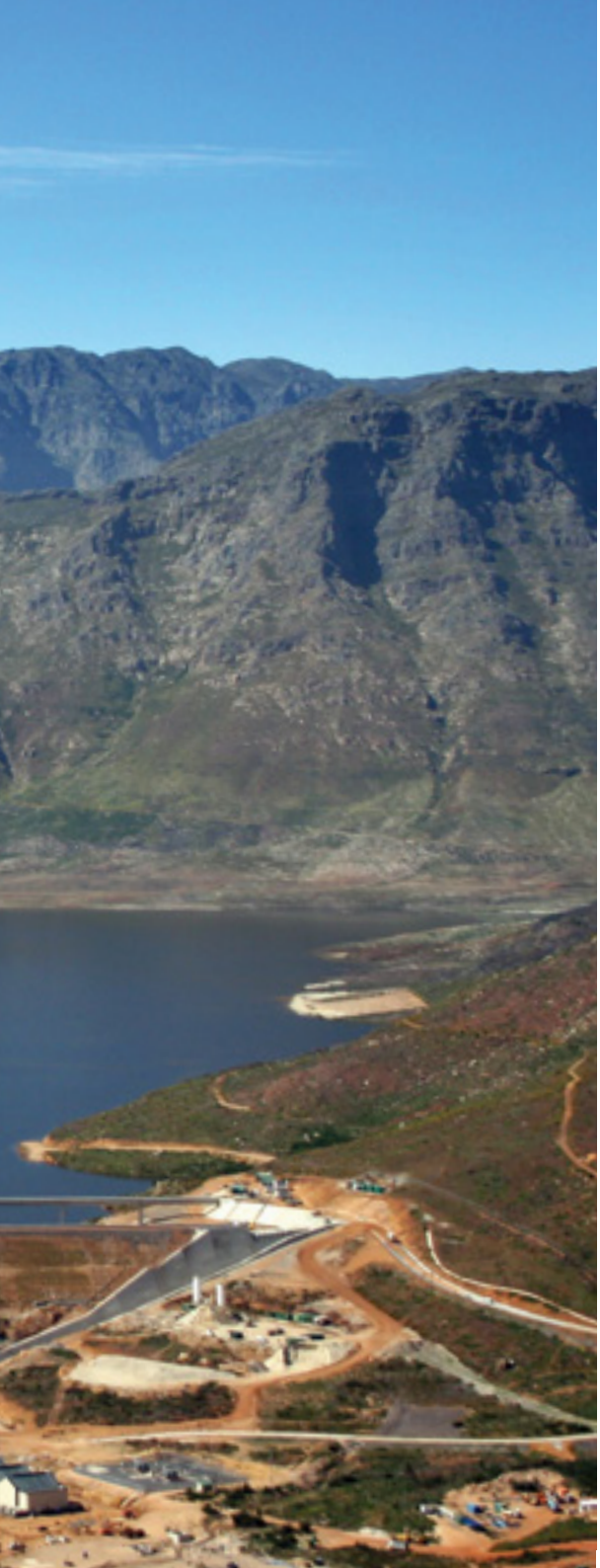
Courses were conducted in Gauteng, the Western Cape and KwaZulu-Natal.

Supporting SA's future water engineers

Water distribution systems are important to supply safe and clean drinking water to people. The Aqualibrium Schools Water Competition, hosted by the South African Institution of Civil Engineering (SAICE), exposes learners, especially those from disadvantaged backgrounds, to the practical application of water-supply processes. They are made aware of the intricacies involved in the design of water distribution networks and the actual delivery of water to households. This competition strengthens Government's initiatives aimed at encouraging learners to take mathematics and science at school and to follow a career as a science or civil engineering professional. During the year under review, the WRC successfully came on board as the main sponsor, a valuable and mutually beneficial arrangement to contribute towards addressing the scarce-skills situation in South Africa. Around 100 learners participated in the final round of the event.

KNOWLEDGE REVIEW 2012/13

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2012/13 financial year. This reflects the organisation's strategic focus based on assessment and integration of the needs, opportunities and priorities presented by the current context and challenges facing the water sector in South Africa, and globally.



KSA 1: WATER RESOURCE MANAGEMENT

EIMAN KARAR | EXECUTIVE MANAGER

KSA 1: WATER RESOURCE MANAGEMENT

SCOPE

Demands placed on water resources arise from a combination of factors: growth and development, increased human and animal populations, increased urbanisation, and climate change and variability. Strategies for reducing demand, increasing efficiency on a catchment basis, and creating new sources of water resources from, for example, desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., provide complementary strategies within the National Water Resource Strategy that can form part of Outcome 6 of Government's key focus for 2014, namely, 'an efficient, competitive and responsive economic infrastructure network' which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', is directly addressed by these strategies.

Climate change can exacerbate competition over scarce or inequitably allocated resources. This leads to tension and conflicts such as those seen in some parts of Darfur. The agreements reached in COP17 and subsequent COPs will have direct implications for how water will need to be central to climate change discussions beyond the Nairobi Programme. South Africa has brought water into the National Climate Change Response White Paper and aspires to streamline water in the South African Climate Change Response Strategy. This will highlight the need for good climate projections, especially relating to rainfall. Enhanced downscaled models from the Global Circulation Models and the use of new technological advancements for remotely-sensed data will be central in adapting to climate change.

A solution proffered by a recent study shows that to achieve a balance in water allocations, scaling up the water development process to a river basin level will require stronger integration of national processes with regional economic and social growth and development to meet the projected temporal and spatial water decline challenges; in effect the convergence of national and regional economic processes is a key step towards stronger shared river basin management. As the African Development Bank's Regional Paper for Africa (2009) notes, "regional integration is essential not desirable".

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological measurements and how these are interpreted in water resource simulations as well as other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes will depend heavily on accurate and reliable data at appropriate spatial and temporal scales. The KSA has invested considerably in enhancing the estimates for quantifying water use and water availability, and has contributed to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the national information system on water resources. Furthermore, the need for integrating surface water and groundwater models has been highlighted. A concerted effort has been made to bridge this gap, starting with improved evapotranspiration estimates which take into account the unsaturated zone, informed by groundwater dynamics.

The bulk of the research in this KSA is in support of Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 1, 2, 3 and 4. Thrust 5 supports Output 2: 'Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality'. Thrust 3 also addresses aspects of Output 3: 'Protected biodiversity'. Further details will be provided in the respective thrusts and programmes.

OBJECTIVES

The main objective of research in this KSA is to provide the water resource management tools for addressing the above challenges, fundamentally driven by increasing water scarcity in the face of increasing and competing demands, all of which have social, economic and environmental consequences. This therefore necessitates proactive, innovative, scientific, technological and institutional experientially-based solutions. A better understanding of water resources and their management requires a more holistic conceptual framework encompassing regional-scale hydrologic systems, land-atmosphere interactions and the biogeochemical cycles that control contaminant transport. This unit operates in five thrusts, the management of which is specifically designed to meet this need. These thrusts inevitably have areas of overlap, which are described below in their respective scopes. Holistic approaches to water resource management are particularly pertinent in this area of research and must take account of all sources of water from quality, quantity and accessibility perspectives.

These objectives are achieved in support of the desired impacts on the lives and health of people, on the economy and on the environment, as articulated through the Government performance outcomes.

THRUSTS AND PROGRAMMES

The research portfolio for 2012/13 was organised within the following thrusts:
Thrust 1: Water Resource Institutional Arrangements
Thrust 2: Water Resource Assessment and Planning
Thrust 3: Water Quality Management
Thrust 4: Water Resource Protection
Thrust 5: Water Resources and Climate
The scope of the strategic thrusts and programmes within KSA1 is as follows:

THRUST 1: 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 a 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.

Programme 1: Water governance and institutional reforms	Scope: The principle of subsidiarity, or, as sometimes referred to, democratisation of water resource management, has brought about challenges, 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 to 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 in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Benchmarking and best practice are crucial here to accelerate learning.

Programme 3: Pricing and financing WRM	Scope: The issues of financial sustainability, affordability of charges by users, transparency and corporate governance are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good groundbreaking 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 charge 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 assigned 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 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 employ a phased approach to adding more and more layers to the scenarios, and to enable scenarios to be customised for localised aspects that need not be of national interest.

THRUST 2: 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 resource infrastructure management, the awareness of the poor state of water resource 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.

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 DWA. 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 water 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. In this programme, the continued deterioration of hydrological gauging processes and other installed earth measurement devices will be addressed through the intensive use of new data sources from remote sensing coupled with the limited earth-based measurements.

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 system 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 allow for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs as expressed in the objectives of Water for Growth and Development as well as through accounting for other factors, which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals. Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water uses will be investigated and included as part of future water resource plans.
Programme 4: Water resource infrastructure	Scope: There is an increasing need to develop systems for the efficient maintenance of the aging water infrastructure as the demand for the development of new and expensive water resource infrastructure is increasing due to the growing economy and population growth. This programme will seek to develop strategies and priorities for water resource infrastructure development and management to address the uncertainties and risks associated with climate change. While built infrastructure development such as dams, reservoirs, irrigation and flood barriers, are important options for addressing these issues, this programme will also explore the potential use of natural infrastructure such as wetlands, floodplains, artificial recharge (to aquifers), etc., to complement built infrastructure (but with an added advantage of healthy ecosystems).

Programme 5: New water	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 and water transfers, be they national or international, from desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. The initial development of research under the new theme of Water and Energy will be initiated through this programme. Within this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention, to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.

THRUST 3: WATER QUALITY MANAGEMENT

Scope: This thrust acknowledges the significant water quality problems in our natural water resources. Water quality is generally reflected in concentrations of substances and microorganisms, physico-chemical attributes, radioactivity, as well as biological responses to these. Within each of the programmes within this thrust, research will focus on two broad fronts, namely, (1) consolidation and knowledge transfer and (2) alertness to emerging issues. Consolidation is necessary of the vast amount of existing water quality-related research outputs in priority domains. The primary aim will be to distil effective decision support for management of our water quality problems. Emphasis will therefore be more on formulating solutions than on formulating problems. By actively sharing knowledge with decision makers, and working closely with them, the decision support must explicitly address their absorptive capacity in its broadest sense. On the one hand, solutions need to be based on a thorough holistic and realistic examination of likely consequences of implementation of those solutions. This must create confidence that risks of unintended consequences will be minimised. However, on the other hand, solutions must cater for the inherent complexity (and hence uncertainty) of both the organisational and natural environment. Research will also be encouraged that heightens awareness, and/or recommends management approaches, specifically to important emerging issues, i.e., those potential or recognised concerns that are either not addressed, or are

only partly addressed, in current water quality management practice and research. High priority issues include those of national concern, those for which the frequency or probability of adverse conditions occurring is high, and the consequences are severe, and so on. Water quality necessarily cuts across various KSAs as well as thrusts within this KSA. The scope of this particular thrust focuses primarily on water quality of inland surface waters and its management.

Programme 1: Water quality monitoring	Scope: Sound water quality monitoring data are crucial to sustainable management because they provide information on the current status and trends. Creative yet soundly-scientific approaches to monitoring are required that optimise information and minimise costs. All phases of monitoring design need careful consideration, from data acquisition, data storage and management, information generation and dissemination, through to realistic implementation strategies.
Programme 2: Water quality modelling	Scope: The programme will encourage a move to open-source modelling platforms that benefit individual model developers, while allowing effective interfacing with other modelling modules in a way that provides integrated, scientifically-defensible water quality information. Business models of such platforms must be as much in the interests of users of such information (e.g. catchment management agencies) as the service providers and modellers.
Programme 3: Impacts on and of water quality	Scope: This programme will focus on identifying, characterising, and understanding (1) the changes in the state of water quality in our water resources associated with either point or non-point pollution sources, and (2) the associated impacts of such compromised water quality.

THRUST 4: WATER RESOURCE PROTECTION

Scope: Reliable supply of good quality water is required for the health, environmental, social and economic wellbeing of the country. The National Water Act of 1998 recognises that protection in relation to a water resource means: (1) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecological sustainable way; (2) prevention of the degradation of the water resource, and (3) the rehabilitation of the water resource. There are significant gaps in our knowledge on how to protect our water resources in an integrated manner. While Thrust 3 will look mainly at the quality of the water within our systems this thrust focuses on protecting the water resources, by reducing the quantity of harmful materials reaching the water resources, within a broader framework for all uses. Broadly, research in this thrust focuses on the generation of knowledge and understanding of the catchment processes and land use activities that influence the quality and quantity, negatively or positively, of the water resources. Scientific, technological and institutional approaches that will

help to characterise and address these problems include: (1) assessment, monitoring and prediction; (2) tools and control strategies; (3) innovation to assist with prediction and control; and (4) implementation and technology transfer options. The following programmes support this thrust:

Programme 1: Source water protection	Scope: Source water protection refers to protecting source water (water from dams, wetlands, rivers, aquifers, etc.) from contamination and overuse. Specific driving forces, or a combination thereof, which have an impact on water resources will be researched. Integrated protection strategies and approaches will be researched and tested. The development of source water planning, control and response strategies, to minimise adverse impacts on source waters by reducing pollution risks and securing water availability, is a key component of this programme. The source water protection approach will look at, among others, land use (see Programme 2 below), vulnerability assessments and catchment plans and strategies (for both surface and groundwater).
Programme 2: Land-water linkages	Scope: This programme will enhance our knowledge on the interaction of water and land at various scales. This programme will focus on the driving forces (new developments, emergency spills, erosion, leaks, soil enhancements, etc.) that can impact water resources from land-based activities. The aim is also to research, evaluate and develop common regulatory tools to overcome the challenge of different technical and procedural approaches for water resource and land use management, in order to enhance our water resource protection capabilities. Techniques to delineate, protect and remediate areas, and/or the activities occurring within these areas, will be researched. Research will also be bi-directional where potential impacts on water resources from land-based activities or processes are investigated as well as the impact of water resources on land-based activities (e.g. floods and droughts).

THRUST 5: WATER RESOURCES AND CLIMATE

Scope: Global environmental change, including climate change, has potential deleterious effects on systems, resources and society, and will be superimposed on currently existing stressors such as unsustainable use of water, deteriorating water quality, and land use and demographic changes in time and space. Potential secondary impacts

due to resultant lack of access to adequate water of acceptable quality are likely to also have undesirable impacts on economic growth, food security, health, ecosystem goods and services, as well as community livelihoods. Consequently, adaptation aimed at reducing the country's vulnerability to the currently highly variable climate, under natural conditions and due to human induced impacts, as well as to projected climate change impacts on water availability, is crucial. This thrust accordingly focuses on developing the understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales. The focus is also 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, but is not limited to, development of tools and systems (e.g. weather forecasts, model scenario projections or early preparedness) for among others, managing floods and droughts and the effects thereof on the resources and the people who rely on those resources, with special emphasis on water quality (e.g. trophic waters) and quantity (due to increased evaporation rates and other) impacts.

Programme 1: Predictive tools	Scope: The need to prepare the country to cope with global climate change and regional climate variability 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. This programme will therefore focus on the following key issues: select and use GCM-generated scenarios of global climate change of appropriate confidence level as a basis for development of model projections; improve techniques for downscaling of scenarios from global (GCMs) to regional and catchment scales to enable or support management at higher resolution scale and to ensure high level of reliability and robustness; improve on detection and attribution of anthropogenic impacts of climate change in the Southern African context in order to distinguish those from natural climate variability and change-related impacts.

Programme 1: Predictive tools (continued)	The programme will also deal with: the choice of relevant and appropriate climate indicators and variables as well as monitoring systems that need to be in place in this regard; determination of the frequency and magnitude of resultant extreme rainfall and flow events; use of existing conceptual and numerical models to utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely inter-related land-use, ecosystem, hydrological (including geohydrological), water yield and water quality changes at regional/catchment level; modification of existing management strategies and tools for adaptation purposes; determining the likely socio-economic impacts for a given structure of society in Southern Africa; and appropriate technological, social and political coping strategies. Other areas that will be attended to include: improving understanding of and forecasting of the variability of rainfall, flow and groundwater recharge, as the ability to forecast at very short time scales would greatly benefit flood management and disaster mitigation and adaptation activities; and improving the understanding of global climate change impacts and vulnerability for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and adaptation actions. Through this programme, support will be provided for weather and climate disaster mitigation programmes at various levels which will include regional, national and provincial as well as other, more localised, scales.
Programme 2: Climate change risk, vulnerability and adaptation	Scope: Climate change risk management seeks to promote sustainable development by reducing vulnerability associated with climate risks. The approach involves a range of actions including reduction of vulnerabilities or enhancement of resilience amongst people and societies, protection of ecosystem goods and services, early response systems, strategic diversification, and improved institutional capacities. Climate adaptation refers to the ability of the system to adjust to climate change, variability or extreme to moderate potential damage or to cope with the consequences. This programme is aimed at reducing vulnerabilities among communities and people through development or implementation of systems, tools, approaches and strategies (some of which would have been developed under Programme 1, such as modification of structures or implementation of early preparedness programme for extreme events). Protection or restoration of ecosystem goods and services that are vulnerable to climate variability and change as well as strengthening capacity of people and institutions are some of the techniques that will be investigated under this programme.

Programme 2: Climate change risk, vulnerability and adaptation (continued)	Climate risk management strategies to be developed under this programme also aim to maximise opportunities in climate-sensitive economic sectors, even under uncertain climatic conditions of high variability. The programme could also deal with implementation of capacity building and awareness programmes including sharing of climate information as part of a broader adaptation programme.
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. The most vulnerable communities are often those who are poorly resourced since they barely have means to cope, and also often live in informal settlements notorious for being drought- or flood-prone with poor infrastructure. 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.

BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed and approved funding budget, inclusive of roll-over, of R31 619 133. Available funding to support running projects within the five thrusts in 2012/13 was R 22 816 533. The committed and approved budget for new projects was R8 802 600. The consolidated budget for the research portfolio is presented below:

Research portfolio	Approved 2012/13 (R)
Current projects	22 816 533
New projects	8 802 600
Total	31 619 133

CORE STRATEGY

Strategic context

The 'water crisis' the world community faces today is largely a governance crisis, according to the OECD, in a comment made in late 2011: "The real challenge is 'implementing' the existing solutions on the ground, tailoring them to local contexts and engaging all stakeholders. Well-functioning institutions underpin increased and more effective investments in water development, hence the importance of the governance-financing nexus. Concrete and pragmatic tools can help diagnose governance challenges *ex ante* and design adequate responses to address the complexity in the water sector." These issues are by no means different to what South Africa faces in the water sector. Similar challenges faced in South Africa include: institutional fragmentation, mainly **poorly coordinated multi-level governance vertically and horizontally; limited capacity at the local level to participate in water-related decision making; and a struggling allocation reform process.** Inadequate means for measuring performance have also contributed to weak transformation and reforms. These obstacles seem to be rooted in the insufficient definition of policies and regulations related to the National Water Act and the overall lack of common vision regarding water in the tri-central focus of economy, society and the environment.

It is known that there is no one-size-fits-all answer or magic blueprint to respond to governance challenges in the water sector; rather, local and spatially-defined policies integrating boundary specificities and local concerns, water management institutions, catchment management agencies, water user associations, transboundary commissions, etc., are at different developmental stages but tend to face common challenges, which will need to be examined, with the benefit of hindsight, to provide adequate policy responses. In order to do so, there is a pressing need to take stock of recent experiences, identify and document good practices and develop pragmatic tools across different levels of government and other stakeholders for engaging shared, effective, and implementable water policies.

A main effort in this KSA will be to continue understanding the water cycle and how it operates, how it affects land-use practices and is affected by them and other atmospheric and anthropogenic processes. **Climate change and the focus on allocating scarce water resources will require strategies for managing demand, increasing efficiency, and creating new sources of water** from desalination, fog harvesting,

targeted recycling, reuse, artificial recharge, etc., which can be viewed as part of Outcome 6: 'An efficient, competitive and responsive economic infrastructure network' which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', relates to these pertinent aspects.

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological 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 heavily in enhancing the estimates for quantifying water use and water availability. This year, the KSA also contributed to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the national information system for water resources. Furthermore, the need for integrating surface water and groundwater models has been highlighted. Concerted effort was made to bridge this gap and to create a continuum, starting with improving evapotranspiration estimates, which take into account the unsaturated zone informed by groundwater dynamics.

The marked inequities in the physical, social, as well as institutional, access to this important resource remains a challenge, mainly to the poor and the disempowered majority whose ability to pay for water is limited. Delivering water services to this majority and ensuring that there are adequate water resources for new productive users, such as emerging farmers in rural areas, is a main target of Outcome 7: 'Vibrant and sustainable rural communities and food security for all'. Output 1: 'Sustainable agrarian reform' is a major focus for the KSA dealing with Water and Agriculture, but in this KSA the main focus is from the perspectives of climate change and adaptation, resource assessment and the institutional arrangements pertaining to addressing equity aspects. In all of the above, the need to safeguard society and the economy through early-warning systems has been identified. Research results need to be shared and communicated effectively to be optimally used for the benefit of South Africa and further afield.

It is worth noting that the bulk of the research in this KSA is in support of Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 2, 3 and 4. Thrust 5 is in support of Output 2: 'Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality'.

Thrust 3, which deals with water quality, identifies eutrophication as being of most concern, followed by increasing salinity. If only two high-priority problems were to be identified to focus immediate research efforts (in the next year or two), they would be microbial pollution and eutrophication. However, all of the main water quality problems would need some attention over the next five years to ensure their current research bases do not stagnate.

The KSA's contribution to the national service-delivery-based outcomes is hence through conducting research that can yield impacts on sustainable development's triple bottom line, through i**mproved water allocation and optimisation of water use between social development, economic growth and environmental sustainability.**

Water and society

The National Water Act places emphasis on stakeholder participation in water resource management, which forms a blend between decentralisation and democratisation for decision making. Vast resources have been used in ensuring that adequate consultation takes place, without necessarily reflecting much value from those investments. International literature confirms that empowerment is a long path which is progressive in nature and highly non-linear. Since the primary focus is to make an impact on the lives of people, the KSA has commissioned studies to establish the lowest appropriate level for decision making in water management in South Africa, the benefits from such engagements and their impact on the lives of women and the poor. The role of local government as the democratic representative in water-related decision making in South Africa is an area that needs further investigation.

Water and the economy

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 rise.

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 subsequently the consequential adaptation needs for the economy; 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 than 15 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 this research cycle, the KSA strategically allocated all of the solicited funding for the purpose of furthering the studies relating to climate change impacts on society, economy, health and the environment, and on majority water uses such as urban water supply, agriculture, mining, etc.

Thus, in line with the WRC's 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, completely in partnership with beneficiaries and service providers.

Water and the environment

A review of relative investments in the different impact areas revealed the need for new research in the area of environmental degradation and mitigation, especially from a water use perspective such as agriculture, mining, etc. Environmental functioning within the hydrological cycle and the integrative knowledge for ecosystem-based water resource management is another area of interest. For example, the crocodile deaths in the Olifants River have created collaborative efforts between this KSA, dealing with water resources, and the KSA dealing with ecosystems.

The impact on the environment from the release of energy and the resulting impact thereof on water

resources have formed part of a long-term discussion between WRC and ESKOM, and an agreement has been signed between the two parties to conduct joint research into alternative energies and the international benchmarking of the latest technologies.

Needs analysis

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

- Promoting proactive research which anticipates the nation's water needs and the environmental impacts of management options
- Encouraging multidisciplinary and interdisciplinary research
- 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
- Creation of partnerships with national and international role players in the water management field
- The South African public is the prime beneficiary of research investments with relevance to regional, continental and international benchmarking of the latest technologies.

In continuation from the previous business plan and based on the consultative processes, the research focus of this KSA continued to support policy-making 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 and encouraging partnerships through joint projects with key stakeholders.

The KSA deals with freshwater resources and their management. In 2012/13, the strategic intent of this KSA continued to be informed by regular interaction with numerous stakeholders. During its formal and informal consultation with the various stakeholders, mainly the board of the WRC, and based on new international research and major global investigations, the following broad categories were identified from the previous cycle and continue to be relevant:

Business and the human right to water

The Office of the United Nations High Commissioner for Human Rights' statement in relation to the right to water stresses a number of key factors: sufficiency, accessibility, safety, acceptability, and affordability. In South Africa, the idea of human rights informed the development of the **Freedom Charter**, which in turn greatly influenced the development of the **Bill of Rights** that forms Chapter 2 of the **Constitution.** This sets out the citizen's rights and commits Government to fulfilling them. The right to water requires that states give priority in water distribution and management to water for personal and domestic uses. This prioritization has implications for water management and may require specific systems to manage competing demands. Industrial bodies (including both private corporations and state-owned enterprises) are often major consumers of water. It is predicted that in 2025, industry, rather than agriculture,

will account for most of the projected increase in water use. As a result, industries may substantially affect the availability of water if their water use curtails access to safe-drinking water for personal and domestic uses, either through over-abstraction or pollution of water sources. Building on the significant commitment to action contained in the CEO Water Mandate, it is recommended that industrial water users endeavour to ensure their activities have a favourable impact on the right to water. The CEO Mandate commits signatories to action in the following six areas: direct operations; supply chain and watershed management; collective action; public policy; community engagement; and transparency.

There is a need to help develop a fuller understanding of how a rights-based approach can inform management of all water-related issues. This understanding would better define what it would mean for a business to go beyond a 'do no harm' approach while also building or influencing the capacity and willingness of governments to uphold their position as the primary duty bearer for protecting and fulfilling the right to water.

Climate change

South Africa is a water-stressed country and by 2050 the effects of climate change will be evident. However, each province is unique and the models addressing climate change should be disaggregated to provincial level. There will be a need for interventions regarding adaptation at provincial and local levels. At the same time, agriculture (the biggest user of water) needs to be more efficient in using water and technologies are needed to improve agricultural productivity. **Uncertainty and climate change** go hand in hand. Small uncertainties in the physical processes are amplified into large uncertainties in the climate response. The challenge for policy-makers, planners and environmental decision makers is to understand how the timing and magnitude of impacts may be affected by changes in climate and sea-level rise associated with differing amounts and rates of change in global average temperature. The challenge for climate change research is to develop monitoring and observation systems; refine models to determine the impacts of climate change in a specific area; identify measures to enhance our capacity to adapt (building adaptive capacity) and take advantage of the opportunities presented by climate change; and make information available for those responsible for policy, planning and environmental decision making.

Water pollution and regulation

The Minister of Water and Environmental Affairs has stated that South Africa needs both technology-based solutions and a change in public attitude which can be achieved through education and awareness. Creative programmes are needed to address this at community level. The Minister also maintains that compliance and enforcement are critical. The Department has to bring back the polluter-pays practice and to establish a new guard with a clear mandate, i.e. the blue scorpions, which will control pollution with a heavy hand. Wetland protection is also of utmost importance as wetlands play a major role in sustaining the resource and combating pollution.

Monitoring

The state of monitoring infrastructure and its implications for water resource assessment and management was stated as one of the important issues which could have serious implications for research and research findings. Mapping of water footprints in the whole value chain, and their impact for specific use, is a new water accounting methodology gaining popularity here in South Africa. Application of real-time water assessment models and tools, water security (quality and quantity) to support growth, and targets for 2030 are also

important issues. The large water footprint associated with energy production is gaining importance as water scarcity continues to become more obvious. New energy technologies – from advanced methods of extracting fossil fuels to low-carbon renewable energy – may look appealing, but they exacerbate water concerns, creating unfavourable trade-offs between carbon and water. However, a myriad of technologies – including water reuse and recycling, increases in energy production efficiency, and large-scale distribution – can help with addressing these trade-offs. Going forward, energy technologies' water intensity will often play as great a role as their carbon footprint in determining the future makeup of the global energy mix.

Water scarcity

Water scarcity with regards to future water supply options; new water such as water reuse, return flows, desalination; and the implications for water resource allocation options could require further research. Support methodologies for water resource planning options such as recharge, retention and recycling need to be addressed in a consolidated fashion to satisfy increased demands sustainably. Augmentation options versus new water sources and feasibility studies have been the domain of national planning.

Water quality

Water quality has been a concern for many decades, be it urban, environmental (groundwater, surface, and estuarine), or drinking water. The water quality research portfolio has been diverse and has grown considerably over the years. While all KSAs have had, and still have, water quality-related projects, this KSA has focused mainly on monitoring (from analytical methods through to monitoring system design) and 'status quo' surveys involving direct measurement of water quality in our water resources. However, there has also been some water quality modelling and management-related research. Water quality problems that have been addressed have included eutrophication, microbial contamination, acid mine drainage, increasing salinity, sedimentation, and endocrine system disruption (potentially affecting many animal species). A document produced by the Fund for Research into Industrial Development, Growth and Equity (with government, big business and labour inputs) prioritised microbial pollution as posing "very high" human health, economic and social risks followed by eutrophication and acid mine drainage which each pose "high" economic and social risks. A DWA planning-level review of chemical water quality (it did not consider microbial pollution) noted eutrophication as being of most concern, followed by increasing salinity. If only two high-priority problems were to be identified to focus immediate research efforts (in the next year or two), they would be microbial pollution and eutrophication. However, all of the main water quality problems would need some attention over the next five years to ensure their current research bases do not stagnate. Notwithstanding the historical and current broad research base, all of the above water quality problems remain, and indeed it is widely held that some are worsening. Consolidation of existing research findings and effective knowledge transfer that complements good existing initiatives (like Green Drop certification) is now necessary. Particular cognisance should be taken of the required 'enhanced quality and quantity of water resources' output of government Outcome 10 which attributes the deterioration of water quality to a "systematic eroding of management". This clearly-stated priority should also guide, and indeed strongly influence, further water quality research. Notwithstanding the need for consolidation, the changing natural environment, as well as the fast pace of international technological development in some contexts, and development of management ideologies,

also requires continued alertness to emerging issues. These may range from newly-identified chemicals hazardous to human or animal health, microorganisms, laboratory analytical methods, and so-called 'earth observation' techniques, to novel management approaches (e.g., those that address social issues, social learning, complexity, transdisciplinarity, etc.).

Sectoral and political cooperation

The realisation that water is an embedded sector and needs to be outward-focused emphasises that many decisions around water lie outside the water sector and hence expansion of the stakeholder base is important to affect decisions made around water. Alignment of powers and functions between the three spheres of Government is defined in the respective laws and legislation. However, the complexity inherent in the management of water and other resources in an integrated manner is proving to be a challenge. This requires a cooperative government functioning seamlessly between national, provincial and local spheres. However, the delineation, coordination and support in this value chain have created some blind spots, mainly from a planning and financial point of view. The reform of water allocations can only be successful if there is complete alignment between the responsible Government departments, viz, Trade and Industry, Rural Development and Land Reform, Cooperative Governance and Traditional Affairs, Agriculture, Forestry and Fisheries, Labour, Treasury, the Land Bank, etc. The new National Planning Commission calls for futuristic studies which are able to project alternatives in future scenarios. This KSA is investing in research efforts to further define available options in support of national sustainable growth and development, including a variety of technical, institutional and policy options for improved water allocation and optimization of water use – developed and adapted for basin-level water management.

Overview of technological trends

The National Climate Change Committee (NCCC) mandated the Department of Science and Technology to lead a Technology Needs Assessment (TNA) in relation to climate change in 2007. The TNA shows that, despite remaining uncertainties regarding the exact nature, magnitude and pattern of future rainfall changes in South Africa, it appears that water resources, already under pressure as a result of growing water demand in relation to a finite and limited supply, will be under even greater pressure in the future as a result of climate change.

According to the IPCC Technical Paper on Climate Change and Water of June 2008, major gaps in observations of climate change related to freshwater and hydrological cycles were identified as follows:

- Difficulties in the measurements calculated from parameters such as solar radiation, relative humidity and wind speed. Records are often very short, and available for only a few regions, which impedes complete analysis of changes in droughts.
- There may be opportunities for river flow data rescue in some regions. Where no observations are available, the construction of new observing networks should be considered.
- Groundwater is not well monitored, and the processes of groundwater depletion and recharge are not well modelled in many regions.
- Monitoring data are needed on water quality, water use and sediment transport.
- There is a general lack of data from the southern hemisphere.

- More information is needed on plant evapotranspiration responses to the combined effects of rising atmospheric CO_2, rising temperature and rising atmospheric water vapour concentration, in order to better understand the relationship between the direct effects of atmospheric CO_2 enrichment and changes in the hydrological cycle.
- Quality assurance, homogenisation of data sets, and inter-calibration of methods and procedures could be important whenever different agencies, countries, etc., maintain monitoring within one region or catchment. Better observational data and data access are necessary to improve understanding of ongoing changes, to better constrain model projections, and are a prerequisite for adaptive management required under conditions of climate change. Progress in knowledge depends on improved data availability. Shrinkage of some observational networks is occurring. Relatively short records may not reveal the full extent of natural variability and confound detection studies, while long-term reconstruction can place recent trends and extremes in a broader context.

Satellite radar tools and applications

Wider availability and use of satellite radar in water-use and evapotranspiration monitoring is widely accepted. 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.

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 has applied 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.

Futurist techniques as a tool in water management

Successful management of complex social-ecological systems requires adaptive approaches and a system of continuous learning for building knowledge and effective management practices to interpret and respond to ecological feedbacks. Knowledge generation of such complex systems is an ongoing process which typically takes years to accumulate. Learning is essential for individuals, communities, other stakeholders and

agencies to develop their ability to deal effectively with new situations and to prepare for change and surprise. In addition the cumulative knowledge should be embedded in the management process.

Water-related multidisciplinary complex social ecological systems are all long-term issues, ranging from several decades to centuries. Delayed policies result in very high costs or the loss of mitigation feasibility. Long-term viewpoints and long-term policy are quite important in these cases, e.g., U.N. Millennium Development Goals (MDG). While forecasting – i.e., attempts to predict future states from current trends – is a common methodology, professional scenarios often rely on 'backcasting': asking what changes in the present would be required to arrive at envisioned alternative future states, e.g., the 'Water sector Institutional landscape by 2025' project.

Futurists use a diverse range of forecasting methods including: anticipatory thinking protocols, causal layered analysis (CLA), environmental scanning, scenario method, Delphi method, future history, backcasting (eco-history), back-view mirror analysis, futures workshops, failure mode and effects analysis, futures biographies, futures wheel, technology roadmapping, relevance tree, simulation and modelling, social network analysis, systems engineering, trend analysis, morphological analysis, etc.

These tools can be explored to assist in making the right choice between different management regimes. Plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Futurist predictions may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline.

Water accounting

Accurate information on, and understanding of, the quantity of water that South Africa has available are important for making decisions regarding sustainable and effective water use. Just as financial accounting is essential for the successful operation of a business, standard water accounting practice is needed to provide support, security and confidence in water planning, water allocations and in support of cost-effective investments in water infrastructure. To manage our water resources effectively and sustainably we need to know how much water there is, where it is, who is using it, and what it is being used for. This will be done by building on the water resource measurement, monitoring and reporting activities already undertaken, such as the National Water Resource Strategy (2004) and assessments such as WR2005 as well as other planning instruments already in existence. There is always a need to improve measurements and methodologies adopted for measurements from a quality and a quantity point of view. Having and applying national standards for measurement and metering – including knowing the degree of accuracy of each measurement system – will be a crucial step in developing nationally-compatible water accounting systems.

Key stakeholders

The major stakeholders remained to be the following five groups:

- The Minister of Water and Environmental Affairs; shareholder
- The Parliamentary Portfolio Committee on Water and Environmental Affairs

- Government departments representing a major group that has a large stake in the research conducted, especially DWA 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 according to the National Water Act
- Other departments such as the Department of Mineral Resources, the Department of Energy, the Department of Science and Technology, the Department of Cooperative Governance and Traditional Affairs, the Department of Agriculture, Forestry and Fisheries, the Department of Health, the Department of Rural Development and Land Reform, Working for Water, the National Planning Commission in the Presidency and the related Portfolio Committees of Parliament represent the other stakeholder groups
- Major water users including farmers, mines, industries, energy, water service providers and civil society
- Academy of Science of South Africa (ASSAf) is a long standing partner to the WRC. The KSA supports ASSAf in water resource matters and is a Deputy Chair of the National African Academies of Sciences Water Working Group.
- Orange-Senqu River Commission (ORASECOM), a partner on the Organising Committee of the International Water Conference to take place in November, 2012
- South Africa shares many rivers with its neighbouring countries; therefore, the governments and major water-user groups from these countries constitute the fifth group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.
- Water use communities at large

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 those of the petroleum, paper, energy, sugarcane and forestry industries, and the information technology industry, such as Siemens.

International players

As in previous years, the WRC maintained its peer review and best practice through continuous interactions with international role-players. Some of its major international partners include:

- CapNet, and a number of their extended networks
- The World Water Council, of which the WRC is a member
- United Nations Agencies such as the UN Environment Programme
- The WRC is the Chair of the Southern Africa Regional office of TIGER which is an initiative of the European Space Agency (ESA) in collaboration with SANSA, the South African National Space Agency, and DWA

- The WRC is the Secretariat of the UNESCO International Hydrological Programme (IHP) National Committee
- The WRC is the Chair of the SANCHIAS 2012 Conference Organising Committee
- Together with GWP Southern Africa, the WRC is reviving the Country Water Partnership and is a member of the SATAC, the GWP Southern Africa Technical Advisory Committee
- The WRC is also a partner in the IWA as the chair of their Groundwater Working Group
- In WISA, the WRC is the Chair of the Legal Subcommittee of the Management Division
- Numerous partnerships, at a project level, exist with the World Bank, the UNESCO IHE, University of Osnabrück, United States Geological Survey

KSA members are invited internationally to make technical contributions in most of the fields relevant to this KSA, mainly institutional governance, climate change, water quality, water resource protection and groundwater and hydrology research.

RESEARCH PORTFOLIO FOR 2012/13

During the past funding cycle the research community was given the opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. The 2012/13 plan was informed by the needs expressed by the board of the WRC and the Minister's committee on improving business processes within the DWA, as well as by the 50-year planning horizon of the National Planning Commission. Broad stakeholder inputs, as well as continuous interactions with various strategic partners, have informed the portfolios.

The primary objective of the research in this KSA continues to be 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 2012/13 addresses this primary objective through the Government delivery Outcomes 6, 7, 9 and 10, and as reflected by the following secondary aims to:

- Broaden the scope for policy and institutional studies to deal holistically with political, legal, economic, compliance and implementation aspects
- Improve water resource information systems and access to data
- Create focus for water quality research by prioritising two crucial concerns: eutrophication and microbial contamination while dedicating attention to implementation challenges
- Protect water sources in a comprehensive and integrated manner by focusing on supporting implementers
- Mainstream climate change discourse to pay closer attention to water

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 2: Compliance and enforcement

Embedding property rights theory in cooperative approaches to the management of aquatic ecosystem services in South Africa
Duncan Hay and Associates; SANParks; Monash University South Africa; Prime Africa Consultants
No. 2073

In South Africa, with a growing appreciation of water scarcity, we have seen a shift away from the notion of ownership to rights of use. This shift marks explicit acknowledgement that water and the associated ecosystems need to be understood and managed as common pool resources. As our understanding of the links between ecosystems and society has developed we are encouraged to view ecosystems as providers of services from which we can derive benefits. Society's interest in aquatic ecosystems is thus focused on how the benefits of access to and use of services should be apportioned, a process that requires trade-offs and collective decision making. The need to allocate rights to benefit from ecosystem services that are highly variable in time and space stresses the central importance of understanding the concept of property rights in the context of common pool resources and embedding this in dialogue addressing the sharing of benefits. A scan of the international literature indicated that well developed and specifically detailed property rights regimes might contribute significantly to the equitable and efficient governance of common pool resources. With this in mind, this report:

- Explores the salient attributes of property rights regimes, particularly common property regimes that sustain cooperative approaches to management over long periods of time
- Identifies property rights knowledge gaps in the management of water resources in South Africa
- Analyses national policy and legislation with a view to assess the extent to which property rights theory and understanding have been integrated
- Develops a collective understanding of how property rights regimes, particularly common property theory, influences the management of aquatic ecosystem services in South Africa
- Services the WRC knowledge hub and those who benefit from it, by contextualizing property rights within the water sector

Cost: R600 000
Term: 2011 - 2013

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Management of human-induced salinization in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity
University of Stellenbosch; University of the Western Cape; CSIR; Department of Agriculture, Forestry and Fisheries
No. 1849

The objectives of this work were to (a) quantify water and salt balances for various land uses and farm management practices, (b) set up a hydrological model of the Sandspruit catchment for predictions of salt loads to the Berg River, and (c) develop land use regulation guidelines in terms of salt generation capacity. Results showed much higher evapotranspiration in the Renosterveld than in the wheatfield. This explained the lower water table levels in this area and why rising water tables in the cultivated land increased saline seep into the river. Although salt is still being naturally imported into the catchment via rainfall and wind, this increased saline seep has been increasing the salinity in the Berg River for decades. Guidelines for managing land use involved the following main factors: the ratio of area covered by perennials (like Resnosterveld) versus annuals (like wheat); the cultivation practice; the presence of contour banks; the occurrence of salinity in the landscape; accumulation of water in the landscape; and the routes water uses to reach the river.

Cost: R2 964 000
Term: 2008 - 2012

Development and application of global navigational satellite systems methodology for groundwater resource assessment
Umvoto Africa; Department of Rural Development and Land Reform; Overstrand Municipality; Purdue University
No. 1851

This study, through its involvement in particular aspects of global navigation satellite system (GNSS) technology related to water resources, contributes substantially to a broadening of the vision in the South African Earth Observation Strategy (SAEOS) framework for coordinating and integrating South Africa's Earth Observation capacities through the full spectrum of geosphere levels, from lithosphere to hydrosphere, atmosphere and ionosphere. The specific aims of the project were: (1) to demonstrate the use of high-precision GNSS technology as a tool for groundwater resource monitoring and assessment; (2) to develop the methodology for relating GNSS measurements of natural or abstraction-induced surface deformation and conjunctive hydrogeological data in order to derive the in-situ, bulk elastic properties (e.g. skeletal compressibility) of an underlying confined fractured-rock aquifer; and (3) to build South African capacity to establish the hydro-geodetic technical infrastructure and implement the data-processing methods required for groundwater resource monitoring. The study methodology had three main components, namely: (1) hydrogeological monitoring network (including borehole network with logged water levels, pumping regimes and water chemistry monitoring, pumping test results and weather station); (2) geodetic monitoring network (including TrigNet site HERM, later becoming International GNSS Service (IGS) site HNUS, three global positioning system (GPS) monitoring sites installed on the sites of production boreholes and the establishment of GPS data-processing infrastructure and software); and (3) combined hydrogeodetic synthesis of cGPS-derived deformation and hydrogeological forcing factors in order to establish elastic compressibility properties of the Gateway aquifer relevant to the improved calculation of groundwater storage and yield. The hydro-geodetic analysis in the case study area showed that the horizontal displacements at the Hermanus GPS sites are closely aligned with the calculated horizontal velocity components of the Nubia plate relative to the International Terrestrial Reference Frames (ITRF) reference frame. The vertical displacements at the Hermanus GPS sites show varying long-term trends (upwards at HGW1, downwards at HGW2 and flat at

HGW3) with a high frequency of peaks and troughs that correlate between sites but do not have a clear link to pumping or atmospheric phenomenon at a daily (one session per day) time-scale. At a shorter time-scale (eight sessions a day) the vertical movement at HGW3 (relative to HNUS) shows a clear downward movement followed by an upward movement in response to a pump switch off at GWE06. This may be due to a stress effect in the aquifer after pumping that could be explained by the Noordergum Effect.

Cost: R1 000 000
Term: 2008 - 2012

A comprehensive short- term heavy rainfall forecasting system for South Africa with first implementation over the Gauteng Province (SHORTRAIN)
University of Pretoria; Agricultural Research Council, Bureau of Meteorology, EUMETSAT; Finnish Meteorological Institute; South African Weather Service
No.1906

The aim of this project was to develop an ingredients-based rainfall forecasting system for the summer rainfall areas of South Africa and specifically the Gauteng Province in order to better understand heavy rainfall occurrence over the province. The methodology involved investigation of the thermodynamic conditions associated with heavy rainfall over Gauteng, construction of lightning climatology over Gauteng, identification of the lightning characteristics associated with heavy rainfall and development of a map which indicates convective initiation over South Africa using lightning data. A short-term rainfall ensemble for verification of results using a summer rainfall season was then constructed. The findings were that the January months have the highest monthly average rainfall as well as the highest number of heavy and very heavy rainfall days. The central and north-western parts of the province experience the most events in which the rainfall at a single station surpasses 75 and 115 mm. Significantly high seasonal rainfall is associated with above-normal rainfall in late summer. December is the month with the highest number of lightning strikes and March is the month with the lowest number of strikes. When an average number of heavy rainfall events occurs over Gauteng there is significantly more lightning than the average value.

Cost: R965 900
Term: 2009 - 2012

The hydrogeology of Groundwater Region 10: Karst belt
Dr JP Venter Consulting Services; Engineering and Exploration Geophysical Services; GEOSS - Geohydrological and Spatial Solutions International (Pty) Ltd
No. 1916

This report forms part of a series on the hydrogeology of the various groundwater regions in South Africa. Region 10 (Karst Belt) is the sixth 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), 19 (Lowveld) and 26 (Bushmanland). The hydrogeology of the Karst Belt is described using available data and gives a good overview of the groundwater conditions in this region. Groundwater Region 10 stretches from approximately Delmas and Springs, east and southeast of Johannesburg, respectively, to the Botswana border north of Mafeking, an east-west distance of just over 300 km. It has a

roughly triangular shape extending from the Delmas/ Springs area in the east to a maximum width of almost 100 km in the west where it abuts against granitic basement rocks and a short section of the Botswana/ South Africa border. Region 10 has been subdivided into three areas: (1) Northwest area (between the Botswana border and longitude 27°); (2) Tarlton area (between approximate longitudes 27°30' and 28°), and (3) Pretoria/ Bapsfontein area (between approximate longitudes of 28° and 28° 30').

Cost: 550 000
Term: 2009 - 2012

Delineating quinary catchments for South Africa and modelling their associated hydrology
CSIR; University of KwaZulu-Natal (Durban); Rhodes University; Department of Water Affairs; Southern Waters Ecological Research and Consulting; University of the Witwatersrand
No. 2020

Nested hierarchical catchments are employed in a wide range of applications (e.g. water resource management, conservation planning, environmental impact or flow assessments, climate change or hydrological modelling, etc.). However, quaternary catchments are fairly large topographical units within which the physiography is highly heterogeneous. This makes quaternary catchment interpolation to finer resolutions incorrect. Presently, there are efforts for sub-delineation of catchments both locally and internationally but these efforts are piecemeal. Thus the consistent and standardized methods and protocols for sub-delineation are lacking, and conflicting boundary extractions hinder data sharing and comparison of assessment and monitoring information. Therefore, this project was initiated to produce a fifth-level, quinary catchment GIS layer with linked hydrology, for which the pre-cursors were altitudinal and river network quinary catchments. This report discusses the methodology used in creating altitudinal quinaries and the methodology used to assign daily hydrological data. The methodology used to transpose the daily hydrological data to the river network quinaries is given for the following hydrological information: daily rainfall values; daily minimum and maximum temperatures; daily values of solar radiation; daily vapour pressure deficit; reference potential evapotranspiration; hydrological soils attributes and hydrological baseline land cover types.

Cost: R295 000
Term: 2010 - 2012

HYLARSMET: A hydrologically consistent land surface model for soil moisture and evapotranspiration modelling over Southern Africa using remote sensing and meteorological data
Pegram and Associates (Pty) Ltd; Joseph Fourier University of Grenoble; University of Cape Town; University of KwaZulu-Natal (Westville); Vienna University of Technology (TU Wien)
No. 2024

The purpose of this project was to make substantial improvements to the existing methodology and software implementation for modelling soil moisture information/maps over South Africa (generated in the fore-runner WRC Project K5/1683) in order to provide soil moisture and evapotranspiration data at appropriate scales to institutions responsible for flood forecasting, drought monitoring, crop modelling and catchment management. Through this project an automated modelling system that produces country-wide estimates of soil moisture state (and actual evapotranspiration as

a by-product), at a 3-hour time-step on a 12 km spatial grid, has been established as a practical and useful product which has been adopted for operational use by the South African Weather Service (SAWS) in their national Flash Flood Guidance (FFG) system. This product informs numerous other fields (other than FFG), particularly in agriculture, for which soil moisture estimates are beneficial, such as crop modelling and drought monitoring.

Cost: R1 423 000
Term: 2010 - 2013

Programme 2: Surface water / groundwater hydrology

Nutrient and organic carbon fluxes from small-scale agriculture
University of KwaZulu-Natal (Durban); University of Pretoria; Institute of Research for Development (IRD)
No.1904

An improved understanding of the processes of land degradation, either by sheet or linear erosion, and the impact of these on vegetation cover, land management and fluxes of water, nutrient and organic carbon, constitutes one of the most important evaluation prerequisites for successful improvement of ecosystem functioning. The results of this study showed that on gully formation and evolution, adequate mitigation of linear erosion can only be achieved by lessening soil piping and bank collapse. No-tillage not only decreases soil erosion, but exporting of the mulch (as forage for small-scale farming or as a potential source of energy/ biofuel in large-scale farming) can also reduce soil CO_2 emissions and thus mitigate climate change. The study tends to contradict the popularly-held attribution that overgrazing is responsible for land degradation. A simple shift in the way livestock are managed, where pasture rotation could replace free grazing, could help to rehabilitate the land and increase livestock density in the future.

Cost: R1 639 600
Term: 2009 - 2012

A method of 3-D fracture connectivity determination and its hydrogeological application
University of the Western Cape;
Council for Geoscience
No. 2023

Characterising fractured rock systems is probably one of most challenging hydrogeological problems, due to their heterogeneity. South African aquifers are predominantly fractured. Fracture connectivity and hydraulic conductivity controls groundwater flow and transport processes. Several approaches can be used to characterise fractures; all are based on certain assumptions which are difficult to meet in reality. Fracture geometry and other features are sometimes measurable in the field and based on these measurements a method of 3-D fracture connectivity, based on statistical and 3-D geometrical principles, was developed.

Cost: R300 000
Term: 2010 - 2012

Programme 3: Water resource planning

National water resource planning for operational needs: an update of applied approaches (Phase 1): Integrated modelling for water resource planning and operational management
University of KwaZulu-Natal (Pietermaritzburg); DHI (SA); University of Colorado; Inkomati Catchment Management Agency
No. 1951

The aim of this project was to develop an integrated modelling framework to support water resource managers by meeting some of the modelling requirements identified for water resource planning and operations. This project has demonstrated that integration of independent domain models using OpenMI is possible, and has explained and demonstrated the advantages of model integration in being able to better represent real-world complexity and thus provide a systems view of water resource systems.

Cost: R2 300 000
Term: 2009 - 2013

Programme 4: Water resource infrastructure

Investigation of unsteady flow conditions at dam bottom outlet works due to air entrainment during gate closure
University of Stellenbosch
No. 1914

The Berg River Dam is equipped with the first multi-level draw-off environmental flood release outlet in South Africa and can release flows of up to 200 m^3/s. The outlet is controlled by a radial gate and is protected by a vertical emergency gate. Commissioning tests of the emergency gate in 2008 found that large volumes of air were expelled from the air supply shaft designed to reduce expected negative pressures in the conduit during emergency gate closure. In 2009 the WRC commissioned Stellenbosch University to investigate the air entrainment phenomenon at dam bottom outlet works during gate closure. The study, comprising of tests on a 1:40 scale physical model and a two-dimensional numerical computational fluid dynamics (CFD) analysis, was inconclusive on the cause of the large air releases. Volume I of this report covers subsequent study using a 1:14.066 scale physical model. The accompanying Volume II covers a study using three-dimensional CFD analyses. Simulations of continuous gate closure on the as-built physical model of the Berg River Dam outlet showed predominant inflow of air into the airshaft during emergency gate closure with short high speed air releases while the emergency gate was between 35% and 25% open. The problem was determined to be one of air blowback in the air shaft rather than continuous air release. The cause of the blowback was found to be the constriction of flow at the radial gate chamber. A number of modified model configurations were tested and recommendations were made for future design. The most crucial of these is that flow in high-headed outlets should not be constricted.

Cost: R1 057 800
Term: 2009 - 2012

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

The optimisation of available human, institutional, technical and financial resources to strategically approach deteriorating water quality in SA through innovative and collective effort focusing on sources of pollution in prioritised fashion

Golder Associates Africa (Pty) Ltd; Chamber of Mines; Tshwane University of Technology; Department of Water Affairs

No. 1970

The objectives of the project were to (i) develop an understanding of source-resource relationships in respect of South Africa's surface water and groundwater resources and to capture this understanding in a water quality map for South Africa; (ii) develop a tool based on the above data and possibly additional determinants that could be used to identify hotspots for prioritization and implementation, and (iii) contribute towards strategic intervention in the deteriorating water quality in South Africa. 'Priority' maps were produced that used coloured icons to indicate surface water monitoring points that were 'low', 'moderate', 'high' or 'very high' priority. This priority category was based on standardised rating curves for the following parameters: EC, pH, Na, K, Ca, Mg, Cl, F, NO_3, SO_4, NH_4 and PO_4. 'Source fingerprinting' maps were also produced for each WMA based on the ratios of various combinations of anions. Certain pollution sources are known to have characteristic ratios of anions. Icons were coded by colour and shape which allowed possible generic sources of the pollution to be identified.

Cost: R500 000
Term: 2010 - 2013

Programme 2: Water quality modelling

A large scale study of the human-induced impacts on the microbial and physico-chemical quality of ground- and surface water in the North-West Province, South Africa

North-West University (Potchefstroom); Agricultural Research Council - Grain Crops Institute; University of the Free State (Institute for Groundwater Studies); North-West University (Mafikeng)

No. 1966

The aims of the project included (a) quantifying selected waterborne pathogens, (b) assessing the usefulness of molecular fingerprinting, (c) measuring cytotoxicity, and (d) investigating the risks of consumption of water from sources in the North West Province. Generally speaking, a degree of both chemical and microbiological contamination was evident in some surface and groundwater in North West Province. Some antibiotic resistance was also evident in faecal coliform bacteria and enterococci. There was also some evidence of pathogenic *E. coli*. A social study examined (a) how and for what reasons communities in the province interact with water, and (b) possible differences between two such communities in a high- and low-rainfall area. There were differences between the two community groups in respect of their perceptions of how their water is managed. The uses of water appear to be similar in most communities. The results confirmed that most people have a strong spiritual and cultural connection with water.

Cost: R1 204 800
Term: 2010 - 2012

Investigations into the existence of unique environmental *Escherichia coli* populations
University of Pretoria; City of Tshwane; ERWAT; South Dakota State University; North-West University (Potchefstroom)
No. 1967

Escherichia coli is widely used as an indicator of recent faecal contamination. This is based on the assumption that it does not multiply or survive for long periods outside the intestines of warm-blooded animals. However, several recent studies have reported that some *E. coli* strains are capable of surviving and multiplying in the environment and were present in the absence of any obvious faecal contamination. This raises questions about the suitability of *E. coli* as an indicator. The overall aim of this study was to obtain *E. coli* isolates from local water resources and determine whether or not populations exist that are distinct from that found in humans and warm-blooded animals. In a series of samples from dams in the highveld region, it was evident that there was a high level of diversity within the *E. coli* population isolated from aquatic environments. Although many of the strains isolated could not be distinguished from the sewage isolates, there was some evidence that some plant-associated isolates showed some level of separation from the rest of the *E. coli* population. Future studies could focus on these genetically distinct *E. coli* strains to establish the degree to which they affect interpretation of *E. coli* analyses performed to protect human health.

Cost: R600 000
Term: 2010 - 2013

Programme 3: Impacts on and of water quality

Guidelines for EDC Management in Water Resources: Volume 4: Management Options for EDCs in Catchments
Golder Associates Africa (Pty) Ltd; Zitholele Consulting (Pty) Ltd; Tshwane University of Technology
No.1933

The aim of this project was to provide water resource managers with a catchment perspective on the management of endocrine disrupting compounds (EDCs). Some EDCs cause effects at concentrations orders of magnitude lower than those levels associated with, for example, carcinogenicity. Furthermore, these levels may be below typical limits of analytical detection. While some work has been done on the occurrence and effects of EDCs in South Africa, generally our knowledge of occurrence and effects on people and the environment remains limited. This means that considerable emphasis should be placed on prevention rather than cure. Management strategies include using existing legislation, adaptive management, applying the precautionary principle, the 'duty of care' concept, self-regulatory approaches and incentive-based regulation. Risk management, including structured risk communication which carefully considers perceived risk and acceptable risk, provides a sound overall framework within which to approach EDC management.

Cost: R1 500 000
Term: 2009 - 2012

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Investigation of the fate and transport of selected microorganisms in two simulated aquifer conditions in the laboratory and in the field
CSIR; University of the Free State (Institute for Groundwater Studies); University of the Western Cape; Department of Water Affairs; Insight Modelling Services
No.1905

The objective of this project was to investigate the fate of microorganisms under selected geohydrological conditions. The specific activities undertaken to achieve this included a literature study, evaluation of models that are suitable for South African groundwater conditions, investigation of the fate and transport of the microbes in the simulated aquifer conditions and in the laboratory, and modelling transport of the microorganisms, including simulation of the lab and field results. Detailed formulation of modelling requirements for fate and transport models was also completed and a prototype model was run using curve-fitting algorithms and data. Other findings were that attachment and deposition kinetics of microbes are mainly determined by electrostatic interactions, and that increased temperatures are associated with a substantially higher adsorption rate to particulate matter in an aquifer, while decreasing temperatures play a role in detachment. Studies also showed that transport and deposition behaviours differ between viruses and bacteria as they respond differently to specific chemical and physical factors.

Cost: R1 406 000
Term: 2009 - 2012

Assessment of the prevalence of human viral and bacterial pathogens in rivers and dams in Amathole District Municipality of the Eastern Cape Province of South Africa
University of Fort Hare; University of California; Walter Sisulu University
No. 1968

The aims of this project were to select a series of rivers and dams in the Amathole District Municipality in the Eastern Cape Province, establish the viral, bacterial and physicochemical properties of the waters, assess fitness-for-use, and assess the human health risks associated with the viruses. The Tyume and Buffalo Rivers were chosen. Most of the physicochemical results were within target water quality ranges for domestic use, except for some pH and turbidity values. The bacteriological qualities of the water (based on total coliforms, faecal coliforms and enterococci) in both rivers was poor. Adenovirus, norovirus, rotavirus, hepatitis A virus and enterovirus were found in the Tyume River in 0 to 31% of samples (depending on the virus) and in the Buffalo River in 10 to 43% of samples. Although there are considerable uncertainties associated with the estimated human health risks due to the viruses, indications are that likely risks of infection may be above acceptable levels.

Cost: R680 000
Term: 2010 - 2012

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Tropical systems from the southwest Indian Ocean into southern Africa: Impacts, dynamics and projected changes
Agricultural Research Council, University of Pretoria
No. 1847

This project aimed to investigate the influence of tropical systems (such as cyclones, storms, and depressions) from the South West Indian Ocean (SWIO), over the Limpopo River Basin. These systems are associated with widespread heavy rainfall and subsequent flooding over the Limpopo River Basin. The resultant rainfall over the Limpopo River Basin is historically confined to the January–March period, with a maximum around early February. Less than 10% of the average annual rainfall can be attributed to these systems, yet widespread heavy rainfall events are mostly the result thereof over the region. Deep negative vorticity values are usually confined to regions to the south of the southern African subcontinent while tropical systems are steered towards and into the subcontinent within a warm subtropical upper air ridge. At climate-change time scales, the influence of tropical systems from the SWIO over the Limpopo River Basin is expected to decrease by the late 21st century under enhanced anthropogenic forcing. This is due to a simulated intensification of the subtropical high pressure systems over the northern and eastern parts of the southern African subcontinent, responsible for steering these systems further north, where an increase is simulated.

Cost: 680 200
Term: 2008 - 2012

Modelled sea-surface temperature scenario considerations and Southern Africa's seasonal rainfall and temperature predictability
South African Weather Service; University of Pretoria; Centre for High Performance Computing (CHPC); International Research Institute for Climate and Society
No.1913

The research team developed and then configured an ocean-atmosphere coupled climate model for operational seasonal forecasts. The two-tiered forecasting system administered by the SAWS was also optimized and brought to the standard currently practised by leading international centres which are still running two-tiered forecasting systems operationally. This optimized forecasting system demonstrates large-scale consistent skill improvements over the old system for a number of variables including, inter alia, surface temperature and rainfall. The results indicate that the coupled models are more skilful than the atmospheric general circulation models in predictions over the equatorial regions and in discriminating between hotter or colder events on a global scale. Coupled models were also found to be relatively more robust in reproducing the observed slow evolving inter-annual modes of variability. The coupled model was found to be superior to the uncoupled model in predicting rainfall both deterministically and probabilistically, while the uncoupled model appeared to outscore the coupled model over South Africa in both the multi-model system and the slow inter-annual component that accounts for the sub-seasonal forcing. The main conclusion from this analysis was that the coupled model is superior to the uncoupled model.

Cost: R488 625
Term: 2009 - 2012

Programme 2: Climate change risk, vulnerability and adaptation

Investigation of effects of climate change on eutrophication and related water quality and secondary impacts on the aquatic ecosystem
Golder Associates Africa (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); DH Environmental Consulting cc; University of Stellenbosch
No. 2028

Eutrophication is a process of nutrient enrichment of a water body, either natural or unnatural, resulting in a reduction in species diversity at all trophic levels. Research indicates that the extent of eutrophication has increased in South African water bodies since its discovery in the 1970s, increasing the problems of high concentrations of algae and reduced water quality. Hence, the aim of this project was to investigate the impacts of climate change on eutrophication and to determine effects of resultant decreased dissolved oxygen on aquatic ecosystems. The methodological approach entailed an extensive literature study, interviews with experts and various stakeholder workshops and meetings. Some of the key activities included use of downscaled General Circulation Models (GCMs) to project changes in rainfall and temperature under A2 climate scenarios across the country at quinary catchment level. This information was used as a basis for the identification of impacts on the selected case study systems. This report summarises the water quality modelling exercises carried out for this project, provides an investigation into the impacts of these changes, and provides recommendations for adaptation and mitigation options.

Cost: R1 500 000
Term: 2010 - 2013

Programme 3: Integrated flood and drought management

Extreme events: Past and future changes in the attributes of extreme rainfall and the dynamics of their driving processes
University of Cape Town; University of Edinburgh
No. 1960

The purpose of this study was to investigate changes in the characteristics of extreme rainfall by establishing relationships between existing station data and the daily synoptic states. To achieve this aim, the main objectives entailed producing rainfall station data set that had been quality controlled according to international standards so that these data could be confidently used in identifying key synoptic processes that resulted in extreme rainfall, based on the cleaned station data and atmospheric circulation fields and trends in these. The methodology entailed application of station data quality control to station data obtained from the CCWR, ARC and SAWS. Despite errors and conflicts identified among the datasets, a quality-controlled station data set that could be used in the rest of the study was produced. The regionally specific characteristics of extreme rainfall in South Africa were also identified. Findings were that: summer recorded the highest occurrence of extreme rainfall in all regions with the exception of the South Western Cape and South Coast regions. Based on the results, it was recommended that extreme rainfall regimes should be identified as opposed to general rainfall regimes, an event-based classification procedure of extreme rainfall synoptic circulation modes should be used, a climate change study on projected changes in the characteristics of extreme rainfall CODEX framework should be undertaken, and a downscale to station scale the new CMIP 5 GCM data must be done to compare with contemporary station data.

Cost: R420 000
Term: 2010 - 2012

CURRENT PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Water governance decentralisation in Africa: a framework for reform process and performance analysis
University of Pretoria
No. 1969

The aim of this project in partnership with the World Bank is to provide knowledge about water decentralisation processes in Africa, in particular to understand which variables have a positive or a negative impact on the implementation of decentralisation processes in the African water sector, and which variables could be affected by policy interventions and how. It is also aimed to enable water sector decision-makers to identify and treat properly those hurdles hampering a transfer of water management actions to the lowest appropriate level.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

The development of an institutional adequacy index using the multi-dimensional poverty approach
University of the Western Cape
No. 1971

This project aims to establish a set of indicators to measure the adequacy of water management institutions, to identify what domains - and what indicators within these domains - are required to measure the adequacy of an institution to perform its task, to increase dialogue between different disciplines (social scientists and engineers) by bringing more rigour and numeracy to the social science dialogue (speaking a common language), to bring more rigour to discussions about poverty, to put the spotlight on 'intangible assets' and wellbeing and to introduce the Capability Approach and notions of multi-dimensionality into discourse on IWRM.

Estimated cost: R1 590 000
Expected term: 2010 - 2013

IWRM – from theory to practice
University of the Western Cape
No. 1975

The aim of this analytical project is to investigate to what extent the different ways of knowing water is influencing the implementation of the 1997 water policy in South Africa.

Estimated cost: R1 005 000
Expected term: 2010 - 2013

Advancing Strategic Adaptive Management (SAM) as a framework for implementation of IWRM by catchment management agencies
University of the Witwatersrand
No. 2072

The overall aim is to advance the understanding and practice of SAM as a framework for IWRM in complex social-ecological systems. This will be achieved by:

- Actively partnering with the ICMA to implement the Inkomati CMS in a participatory and adaptive manner that is cognisant of the demands of complex system management

- Develop sustainable and independently functioning participatory decision-making systems in the Inkomati catchment
- Develop a sound working relationship with DWA to integrate planning and decision systems to make the most of commonalities and differences in mandate and operating procedures between DWA (the regulator) and ICMA (the implementer)
- Gain broader international experience and understanding of IWRM and adaptive management practices, thereby further advancing SAM and IWRM in South Africa
- Undertake a programme of knowledge and skills transfer within South African water sector

Estimated cost: R1 637 975
Expected term: 2011 - 2014

Change-oriented learning and water management practices: knowledge flows and mediation tools
Rhodes University
No. 2074

The aim of this study is to:

- Identify two water management practices in the Eastern Cape to investigate and pilot change-oriented learning models and approaches
- Research learning in two water management practice activity systems to identify features of the learning process, and materials for mediating water management practices in this context
- Produce a question-driven resource that will help to inform and support learning processes associated with the water management practices; he resource will pilot new approaches to mediating water knowledge in relation to these practices (e.g. using multi-media tools)
- Test and develop a training process for mediators, based on the learning models and using the resource for mediation
- Research and develop a community-directed resource catalogue to support change-oriented learning; the purpose of this will be to make knowledge resources accessible within the mediation and learning process.
- Theoretically explore the role of knowledge and learning in building a democratic society with a focus on water resource management practices

Estimated cost: R900 000
Expected term: 2011 - 2014

Investigating stakeholder engagement cycles and identities within water resource management, using narrative techniques
The Narrative Lab
No. 2076

This study will be undertaken in collaboration with Monash University and other notable researchers and will focus on investigating the stakeholder engagement cycles and stakeholder identities that impact on effective water resource management within three contexts selected according to current engagement levels. The study will utilise a narrative research paradigm to ascertain the history of stakeholder engagement at the focus sites, to understand and interrogate the cyclical nature of engagement. The study will also aim

to identify the identity discourses that prevail within varying levels of engagement, with a particular focus on the volunteer identity. The second leg of the study will aim to identify the high potential opportunities that occur within stakeholder engagement cycles so that locations with water resource challenges may leverage the opportunities that present themselves in the future for stimulating increased and sustainable stakeholder engagement.

Estimated cost: R746 108
Expected term: 2011 - 2014

Programme 2: Compliance and enforcement

Development of the AWARE model for the Inkomati CMA
University of KwaZulu-Natal
No. 1935

RISKOMAN, a joint project with UNESCO-IHE, aims to develop a policy tool that: (a) can optimise water allocation in multi-purpose multi-reservoir systems in water scarce environments, based on economic values and socio-political preferences; that (b) can continuously adjust these allocation policies based on seasonal flow forecasts and knowledge of their uncertainties; and that (c) can hedge against inflow risks using adaptive, risk dynamic, management and operation strategies. This project adds two extra components to the RISKOMAN research: i.e. (a) The development of an interactive multi-level information system in which information will be provided to different levels of basin water resources stakeholders, with an emphasis on providing the integrated information from RISKOMAN to the level of CMA Board members; (b) improved understanding of the hydrological functioning of the Inkomati Basin through focused research on the spatial and temporal variability of hydrological drivers in the catchment with the use of remote-sensing methodologies and the application of these within the RISKOMAN project as a whole.

Estimated cost: R1 800 000
Expected term: 2009 - 2013

Considering alternative dispute settlement practices for water resources management In South Africa
University of Stellenbosch
No. 2077

This project is aimed at evaluating the need and possibilities for alternative dispute settlement in water resource management, in view of current mechanisms and laws. It intends to ultimately propose alternative dispute settlement mechanisms to complement develop and implement provisions for dispute resolution in water law for South Africa.

Estimated cost: R1 400 000
Expected term: 2011 - 2014

Programme 3: Pricing and financing WRM

Approaches to engaging basin risk and the political economy of water in the Western Cape system
Pegasys International
No. 2075

This study is aimed at: (1) framing possible government and corporate responses at a basin level which reflect the shared risk paradigm, the political economy of water use and the challenges of future development and climate uncertainty. It also intends to (2) improve the understanding of the political economy of water use in a river basin, based on the use and movement of embedded water in goods and services, at subsistence,

local market, regional economic and international trade levels, and considering linkages into food, energy and water security. The study will (3) develop and improve tools and approaches for quantitatively and qualitatively evaluating basin water use and its political economic implications, under future climate and development uncertainties, and (4) foster dialogue between government, corporate and civil society representatives about the use, protection and development of basin water resources to secure political, economic, social and ecological development imperatives, through the lens of shared risk in a basin with increasingly stressed water resources.

Estimated cost: R700 000
Expected term: 2011 - 2014

An analysis of water pricing instruments governed by the DWA water pricing strategy, and its potential for generating revenue for CMAs
Prime Africa Consultants
No. 2078

This project aims to investigate the income potential of various instruments for water resource management. It intends to demonstrate the income potential of these instruments on a case study basis. The results from this study should advise on water pricing and CMA budgeting and financing with the purpose of strengthening CMAs.

Estimated cost: R610 000
Expected term: 2011 - 2014

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The hydrogeology of Groundwater Region 17: Central Highveld
Council for Geoscience
No. 2049

The main objective of this study is to produce a report that summarises and synthesises the fragmental present-day knowledge about the occurrence of groundwater in the Karst Region. The report will serve as a guide in the exploration and further development of groundwater supplies.

Estimated cost: R700 000
Expected term: 2011 - 2013

Developing a citizen-based rainfall monitoring system
Pegasys Strategy and Development (Pty) Ltd
No. 2057

This project aims:

- To synthesise experiences, both locally and internationally, with regards to supplementing rainfall data with differing data sources, particularly citizen-based gauging
- To source and collect citizen-based rainfall data, bearing in mind the need to develop a more systematised manner for submission of this information
- To evaluate citizen-based data against other data sources such SAWS and satellite data as well as broadly assessing the uncertainties related to the various data sources

- To model the impacts of the various rainfall data sources upon the understanding of water resources within the Breede Water Management Area and from this to generate key lessons
- To provide insights into systems issues and requirements together with key role players such as DWA, BOCMA, and SAWS
- To develop some practical steps to improve the rainfall monitoring networks supported by citizen-based networks, bearing in mind the various institutional roles and responsibilities

Estimated cost: R400 000
Expected term: 2011 - 2013

The establishment of rain gauge networks for rainfall estimation calibration of the South African new weather radar network
University of the Witwatersrand
No. 2062

Overall, this project aims:

- To develop a rainfall estimation algorithm using rainfall data from the new S-band dual-polarised Doppler radar at Bethlehem and validated against a dense rain gauge network.
- To achieve the re-establishment of the Liebenbergsvlei catchment rain gauge network, near Bethlehem, as a ground-based validation/ calibration tool.
- To achieve the establishment of a rain gauge network in the Cape Town area, so as to create a validation tool for comparisons between convective rainfall (in the Bethlehem area) and stratiform rainfall (in the Cape Town area).

The aim of re-establishing a network of rain gauges is not only for the validation purposes of this project, but to provide a long-term sustainable network for the validation and calibration of future radar/satellite studies. Such a network is also a good platform to provide a long term record of rainfall data over central South Africa.

Estimated cost: R1 100 000
Expected term: 2011 - 2015

Programme 2: Surface water / groundwater hydrology

The use of isotope hydrology to characterise and assess water resources in South(ern) Africa
University of the Witwatersrand
No.1907

This project will be used to assess the water resources of selected areas, building on new, existing and earlier, uncompleted studies, information and data. The other main aim is to re-establish and develop the required capacity to analyse and interpret isotopic data and information. This will be achieved through the re-interpretation of available isotope data in South(ern) Africa as well as developing new studies whereby the usefulness of isotope hydrology is demonstrated.

Estimated cost: R2 009 200
Expected term: 2009 - 2012

Hydrology of South African soils and hillslopes (HOSASH)
University of the Free State
No. 2021

It has been recognised that there is an intrisic and interactive relationship between soil and hydrology; thus

hydrologists acknowledge that spatial variations of soil properties significantly influence hydrological processes. Attempts have been made previously to link different hydrological behaviour of different soils at a pedon (or small) scale. This study focuses on upscaling this pedon classification system towards hillslope hydrology then to catchment scale and thereby improving our understanding of hillslope hydrology. The main aim of the study will be develop a hydrologically-based classification system of South African soils and hillslopes which will assist in hydrological modelling especially in un-gauged basins.

Estimated cost: R 5 000 000
Expected term: 2010 - 2015

The long-term impact of *Acacia mearnsii* trees on evaporation, streamflow, low flows and groundwater resources. Phase II: Understanding the controlling environmental variables and soil water processes over a full crop rotation
CSIR
No. 2022

The hydrological processes of deep-rooted trees need to be understood in order to improve the granting of licences to water users and for water allocation. Thus this study aims to quantify the long-term effects of deep rooting *Acacia mearnsii* on deep soil water profiles, streamflow and evaporation over a full crop rotation. It will also quantify the controlling environmental and soil water processes and provide a modelling framework for the catchment water balance to improve streamflow predictions (specifically low flows).

Estimated cost: R800 000
Expected term: 2010 - 2012

Surface water, groundwater and vadose zone interactions in selected pristine catchments in the Kruger National Park
University of KwaZulu-Natal (Pietermaritzburg)
No. 2051

This project seeks to define the interactions of groundwater, surface water and the vadose zone within a pristine catchment (within the Kruger National Park). This will form a sound base upon which to facilitate further multi-disciplinary environmental research for extrapolation elsewhere; it will also enable the determination and quantification of scale-dependent hydrological processes in clearly organised landscape sequences in a pristine setting.

Estimated cost: R1 800 000
Expected term: 2011 - 2014

Impact of fault structures on the occurrence of groundwater in fractured rock aquifers
Council for Geoscience
No. 2053

Amongst geological features in fractured rocks, faults are one of the most important geological structures that control the occurrence of groundwater in fractured rock aquifers. Fault-controlled aquifers have been one of the most important wellfield development targets for water supply. Problems often arise from the application of current conceptual models on the evaluation of fault-related aquifers. This is mainly due to many unknown parameters of faults that are often required as input to both qualitative and quantitative models. This study aims to (a) develop multiply approaches to the delineation and characterisation of fault-controlled fractured aquifers; (b) develop sound methods for the establishment of conceptual models of fault-controlled aquifer types which will produce both 2-D and 3-D models; and (c)

estimate aquifer properties and groundwater flow based on established conceptual models, using well-calibrated numerical models.

Estimated cost: R600 000
Expected term: 2011 - 2014

Groundwater-surface water interaction: From theory to practice
University of the Free State
No. 2054

The interaction of groundwater and surface water occurs in a complex hydrological continuum, and several studies have been completed that looked at groundwater (GW) and surface water (SW) interactions from mainly a desktop perspective. Other studies took this further through case studies but there is not much that has been done on the actual measurements of the fluxes between these reservoirs. The main aims of this project will be to: (a) review current state-of-the-art methodologies to measure surface water and groundwater interaction methods at local and catchment scale; (b) set up a data collection network and test various observation methods at a test site; (c) develop appropriate innovative methodologies/approaches to measure surface water and groundwater interactions at a test site and/or either upscale and apply to another test site; (d) assess uncertainties arising from the underlying conceptual-mathematical framework; (e) assess the developed methodologies at test sites; and (f) develop guidelines for other test sites and the best-way-forward methodology.

Estimated cost: R2 000 000
Expected term: 2011 - 2014

Investigation of groundwater potential in fractured crystalline rocks of the North West Province, South Africa
Council for Geoscience
No. 2055

In this research, geophysical, hydrogeological and remotely-sensed data will be used to assess the groundwater potential of the North West Province. The Vryburg area was selected as a case study site because there is a growing need for water. This project will mainly aim to develop approaches that will assist local authorities in developing potential groundwater supply target zones.

Estimated cost: R1 000 000
Expected term: 2011 - 2013

Development of the pressure release flowing test method for artesian flow aquifers with case study in TMG
University of the Western Cape
No. 2058

This project will develop and evaluate methods to test artesian boreholes and estimate aquifer parameters. It will cater for the artesian flow systems associated with semi-confined, locally confined and weakly confined aquifers. The research will be based on existing boreholes identified in fractured rock. A test unit will be developed that will be mounted in pressurised boreholes to measure the required parameters necessary to determine aquifer properties to improve borehole and/or aquifer management.

Estimated cost: R400 000
Expected term: 2011 - 2013

Validation of the forcing variables (evaporation and soil moisture) in hydrometeorological models
University of KwaZulu-Natal
No. 2066

This project aims to:

- Provide data for the continued support of soil moisture modelling of South Africa using a hydrologically consistent Land Surface Model (follow-on project proposed from K5/1683)
- Provide accurate field and satellite estimates of the forcing variables (Eta and SM) for the calibration of hydro-meteorological models
- Evaluate the spatial variability of SM at catchment scale

Estimated cost: R700 000
Expected term: 2011 - 2014

Programme 3: Water resource planning

Enhancements to WR2005 study (completed for the WRC in December 2008)
SSI
No. 2019

The main objective of this study is to enhance the Pitman Model in order to generate patched observed streamflows for areas where rainfall gauging stations have unreliable records (or records are non-existent). It is envisaged to create a complete database of the actual monthly patched observed monthly flow volume for each streamflow gauge.

Estimated cost: R450 000
Expected term: 2010 - 2011

Optimal utilisation of geothermal water resources
UNISA
No. 1959

The principal aim of the project is to determine the optimal uses of thermal springs in South Africa. The project will address the suitability of South African springs for: tourism; balneology; bottling; aquaculture; agriculture; space heating; geothermal energy production; mineral extraction. In addition, this project will be the first study on microbial diversity, including thermophilic organisms, of hot springs in South Africa. Hot spring assessment and characterisation will also be completed.

Estimated cost: R2 380 655
Expected term: 2010 - 2013

Development of a groundwater resource assessment methodology for South Africa: towards a holistic approach
University of the Free State
No. 2048

Project aims:

- Review the GRA II methodology to address identified gaps and improve confidence levels in the current methodology
- Update data sets to address, e.g., distribution of recharge figures, poor distribution of chloride figures, etc.
- Generate data sets for groundwater use
- Revise the methodology and identify data requirements
- Pilot testing of the methodology

Estimated cost: R980 000
Expected term: 2011 - 2013

Implementing uncertainty analysis in water resource assessment and planning
Rhodes University
No. 2056

Project aims:

- To utilise newly emerging field-based information on the various processes involved in surface-groundwater interactions (recharge, storage, evaporation losses, discharge to rivers, etc.) to test and, where appropriate, improve the algorithms of the Pitman model as well as improving the quantification of the relevant parameters, thereby reducing the overall uncertainty in the use of this part of the model
- To further assess rainfall input uncertainties and the possibilities of reducing the uncertainty through the use of different sources of information
- To ensure that the climate change uncertainty assessments are integrated with other approaches designed to reduce uncertainty
- Facilitation to ensure that water resource engineers understand and appreciate the value of including uncertainty and are comfortable with the use of new modelling approaches that include uncertainty
- To determine suitable uncertainty bounds around the existing regional parameters (part of WR2005) of the Pitman model
- To further develop practical procedures for constraining the uncertain outputs from hydrological models using either regional indices of hydrological behaviour and/or observed streamflow data (that may themselves be uncertain)

Estimated cost: R600 000
Expected term: 2011 - 2014

Programme 4: Water resource infrastructure

Structural health monitoring of arch dams using dynamic and static measurement
University of Cape Town
No. 2025

This is a joint WRC-DWA project whose purpose is to develop best practices in ambient vibration testing of arch dams as part of the broad structural health monitoring and surveillance of concrete dams.

Estimated cost: R1 500 000
Expected term: 2010 - 2013

Programme 5: New water

Optimising fog water harvesting
UNISA
No. 2059

Project aims:

- Understanding the physical and chemical complexities of fog and its formation: a) to determine the physical and chemical characteristics of East and West Coast fogs (drop size, density, moisture content, biological and chemical characteristics; b) to determine the factors affecting the occurrence

and moisture content of fog (including the relationship between fog occurrence and rainfall, wind speed, sea surface temperature, upwelling extent (west coast), synoptic conditions (west coast); c) to determine the possible influence of climate change on the fog phenomenon and associated environmental and social impacts

- Optimising the fog water harvesting processes: a) to delineate optimal sites for fog water collection; b) to evaluate different materials so as to identify the most effective fog water collector; c) to assess the impact of the erection of fog water collection systems on the environment; d) to investigate possible alternative uses for fog water
- The development of novel products: a) to design and build a water flow meter for low-flow conditions; b) to design and develop fog water harvesting systems for unique/specific environmental conditions; c) to develop a low-cost optical fog detector with LWC potential; d) to develop new materials for fog water harvesting

Estimated cost: R2 500 000
Expected term: 2011 - 2015

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Implementation of the rule based agent for *Microcystis* in Rietvlei Dam
North-West University
No. 1962

Microcystis aeruginosa has been identified as a common form of cyanobacteria in South African impoundments such as hypertrophic Rietvlei Dam, and has potential to form toxins that can cause illness or death. The project is aimed at determining the effect of solar bees on algal growth and then set up a model for prediction and control of cyanobacterial and other algal blooms.

Estimated cost: R175 000
Expected term: 2010 - 2014

Programme 2: Water quality modelling

Implementation of salinity and water management tools for the Berg and Breede catchments in the Western Cape
University of Stellenbosch
No. 2063

The general aim of the project is to implement salinity management tools at pilot catchment(s) in the Western Cape. The specific aims of the research are: to identify specific salinity-related problems and potential solutions in selected pilot catchment(s) in the Western Cape and to collect baseline data and set up catchment management tools (to populate informational databases, design an ideal monitoring network and set up spatial hydrological models). Activities will also include the following: to assess historic and current impacts of climate and land uses on water resources in multi-functional landscapes with particular focus on specific regional problems (e.g. salinity) and to refine and apply

existing catchment management tools to the selected pilot catchment(s); and to run scenarios/forecasts and recommend land uses to minimise impacts on water resources in multifunctional landscapes with particular focus on specific regional problems (e.g. salinity), taking into account institutional arrangements and socio-economic implications.

Estimated cost: R1 000 000
Expected term: 2011 - 2013

Nutritional factors influencing the biosynthesis of the neurotoxin Beta-N-methylamino-L-alanine by cyanobacteria
Nelson Mandela Metropolitan University
No. 2065

The aim of the research is to determine the role of environmental nitrogen, phosphorus and light quantity and quality on BMAA production by cyanobacteria, and to determine whether BMAA is produced differentially as a function of growth rate or growth phase. The purpose is also to evaluate a range of easily measured metabolites to find those that correlate with BMAA so as to facilitate easy BMAA measurement without expensive equipment and to establish the mechanism of BMAA biosynthesis in cyanobacteria.

Estimated cost: R500 000
Expected term: 2011 - 2013

Programme 3: Impacts on and of water quality

The Manual of Guidelines for Projects on EDCs in Water Resources: Volume 1: Monitoring and Assessment Guide
University of Pretoria
No.1915

The EDC research programme has been developed with the aim to provide aid to stakeholders and the Government in the monitoring and management of EDCs. During the first phases the analytical methodologies have been developed and the programme is now in the phase of developing guidelines on how to monitor and manage pollution to improve water quality or prevent further degradation of water quality. This volume will give guidance on when to monitor, how to do monitoring and, after receiving the data, how to assess and interpret the data for follow-up actions. This will be in line with the National Toxicant Monitoring Programme of DWA. This project will be the first volume of the series of guidelines, and will provide a general background and definitions as well as key issues related to planning and executing an EDC study in a catchment, to be able to make informed decisions to prevent pollution.

Estimated cost: R 1 500 000
Expected term: 2009 - 2012

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Vadose zone hydrology: Spatial and temporal influences, assessment techniques and aquifer susceptibility
University of Pretoria
No. 2052

The safe locating of potential sources of contamination and the mitigation and rehabilitation of contamination can be better assessed based on an improved understanding of the spatial (or lateral), vertical (or horizon-based) and temporal (or time-dependent) influences on vadose zone seepage. This project will

investigate the behaviour of water and solute within the unsaturated zone and evaluate field, laboratory and empirical assumptions currently being made to assess the fate and transport of contaminants in the vadose zone.

Estimated cost: R1 000 000
Expected term: 2011 - 2014

Towards an integrated framework for the assessment and management of sediment-related impacts on water resources in South Africa: A dam performance case
Muondli Consulting and Projects
No. 2064

This project assesses and reviews existing knowledge and literature on existing sediment-related impact assessment and management frameworks. This will cover impacts of sedimentation on major rivers and navigation pathways, aquatic ecosystems, and water supply systems. The project will, as one of the key outcomes, investigate and identify new concepts, technology and data sources that could improve the processes involved in an integrated sediment related impact assessment and management platform. A case study will also be developed that will demonstrate the use of a framework by developing a generic methodology for the analysis of impacts of sedimentation on the performance of dams in South Africa and also apply the developed methodology on selected dams in South Africa.

Estimated cost: R1 100 000
Expected term: 2011 - 2013

Guidelines for the delineation of protection zones in a complex aquifer setting
Groundwater Consulting Services
No. 2288

In this project guidelines will be developed to delineate groundwater protection zones in complex aquifer settings. This guideline will build on the work done by DWA and will include the latest international best practice, minimum data requirements, the latest data collection methodologies and a risk analysis approach. This guideline will be tested at the Rawsonville research site where the fractured TMG aquifer is intersected by a fault and a river.

Estimated cost: R740 000
Expected term: 2011 - 2013

Preventing production borehole clogging by in situ iron removal in South African aquifer systems
Council for Geoscience
No. 2070

This project will test local applicability of the in-situ iron removal technique for prevention of clogging in a primary aquifer and associated boreholes as well as a borehole(s) situated in fractured rock aquifer(s). This project aims to eliminate iron-related clogging problems experienced in SA by eliminating the underlying source. This would be done through preventing high Fe (II) concentrations developing in and mobilising from the aquifer. Studies have been done since the 1970s into prevention of iron dissolution from the aquifer matrix and implemented abroad. To date, a practical rather than a pure theoretical approach into Fe (II) fixation in SA aquifers has not been found and this knowledge gap is what this project aims to address through the proposed research. Based on experiences abroad, the most viable option at the moment to research and apply

to fixation of Fe (II) in SA aquifers would be through the in situ iron removal treatment.

Estimated cost: R600 000
Expected term: 2011 - 2014

Programme 2: Land-water linkages

Water Sensitive Urban Design (WSUD) or Low Impact Design (LID) for improving water resource protection/conservation and reuse in urban landscapes
University of Cape Town
No. 2071

The aim of this project is to assist planners in water management through guidelines on water resource protection, conservation and reuse using WSUD or LID. The guidelines will include holistic best management practices and assist in establishing urban spaces that will protect the health of watercourses as well as how to implement these BMPs. Innovative solutions will be developed for, among others, reducing run-off; minimising effluent discharge; increasing recycling opportunities and reducing water demand. This will be achieved within a catchment management framework. It is expected that this project will build on an ongoing WRC project entitled 'Alternative technology for stormwater management'.

Estimated cost: R2 000 000
Expected term: 2011 - 2014

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Developing climate change adaptation measures and decision-support system for selected South African water boards
Rhodes University
No. 2018

This project is aimed at identifying potential impacts and threats to sustainable water service delivery, posed by climate change and associated uncertainties. The work will be done through application of existing estimation tools. Methodologies for assessing risks and vulnerabilities, monitoring strategy, and decision support framework for adaptive management will be developed. Thresholds of potential concern for water quality and quantity issues will also be derived.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

Projected impacts of climate change on water quantity and quality in the uMngeni Catchment
University of KwaZulu-Natal
No. 1961

Based on the need for suitable assessment and adaptation measures in planning and disaster risk management for possible impacts on water in Umgeni, this project was conceptualised. Hence the purpose is to determine potential impacts of climate change on runoff in the catchment, potential impacts on water quality and dam yield.

Estimated cost: R1 492 000
Expected term: 2010 - 2012

Modelling daily rain-gauge network measurement responses under changing climate scenarios
Pegram and Associates (Pty) Ltd
No. 1964

Monthly streamflow modelling should be complemented with stochastic rainfall runoff modelling that is coupled with predicted future climatic variability or change. The purpose of this project is to establish a link between rainfall and climate change. The meso-scale scenarios that are typically generated by GCMs will be disaggregated into small spatial and temporal scales using probabilistic-stochastic methods. The methodology will entail identifying a subset of available Global Circulation Models (GCMs), whose meteorological time series outputs are plausible in a hydrological context, with particular emphasis on Southern Africa. It will then determine links between climate variability (as modelled by GCMs) and daily rainfall as recorded in meso-scale to regional gauge networks and demonstrate the plausibility of generating stochastic ensembles of future multisite rainfall time series, reflecting plausible future climate changes.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

Unifying weather and climate variability predictions - An operational seamless forecasting system for Southern Africa at time scales from days to seasons
CSIR
No. 2050

This research project aims to analyse a set of regional projections of climate change in extreme events, particularly CCAM over Southern Africa, within the context of anthropogenic forcing. This will be done in order to develop an optimal operational forecasting system for extreme events over Southern Africa that has the potential to bridge the gap between weather and seasonal forecasts, i.e., a seamless forecasting system. The project also aims to develop an operational seamless streamflow forecasting system for South Africa, and an operational seamless tropical cyclone prediction system for the south-western Indian Ocean, as well as to improve communication between forecast providers and forecast users.

Estimated cost: R950 000
Expected term: 2011 - 2014

South African climate multidisciplinary analysis
University of Cape Town
No. 2060

The aim of this research project is to provide an improved conceptual understanding of ocean-atmosphere linkages to hydroclimatic variability in Southern Africa at relevant spatial and temporal scales, with a focus on drought and wet period, the cause of non-linearity between ENSO and Southern Africa hydroclimate and the causes of decadal fluctuations of the ENSO Southern African hydroclimate relationship. This will be achieved by characterising the South African rainfall regime and the evolution of rainfall characteristics and hydrometeorological parameters with climatic fluctuations, documenting the impact of ENSO on the winter rainfall region, assessing the adequacy of models used for seasonal forecasting or climate change scenarios and reviewing and improving knowledge related to the future state of the oceans and coastal regions of Southern Africa. Other tasks will include documenting and understanding the changes in ocean temperature and the Southern African hydroclimate, and the link between the two, over the past 25, 50 and 100 years, and to train students

and researchers in data analysis of large and complex datasets, such as the huge dataset generated by high resolution coupled models or satellite remote sensing.

Estimated cost: R1 200 000
Expected term: 2011 - 2014

Development of defensible regional climate change projections for adaptation and policy
University of Cape Town
No. 2061

This research project aims to explore the changes in regional rainfall in relation to climate processes on multiple scales, and so develop more confident understanding of the regional expression of anthropogenic climate change in relation to natural variability. Methodologies include the following:

- Assess techniques in probability/uncertainty analysis for application to South African climate change projections, drawing on existing literature, perturbed physics simulation techniques, and contextualised by understanding of natural variability
- Integrate emerging data sources, especially from multiple models of CMIP5 and CORDEX, along with local institutional climate modelling activities, to support the development of regional climate change projections with associated measures of the envelope of possibilities and uncertainty.
- Develop region-relevant skill assessment of model and downscaled climate change projections, and apply appropriate measures for evaluating the quality and value of the different data sources so as to maximise the development of robust interpretations and probability measures.
- Develop and test a framework for incorporating the advances of the above aims into a robust approach to developing regional climate change projections, with appropriate support information on probability and confidence.
- Leverage the value of existing perturbed physics model simulations for South Africa (from the UCT/Hadley centre collaboration) to strengthen the assessment of possible attribution of regional climate change.
- Incorporate new knowledge into existing climate service activities for the dissemination and communication of regional climate change and incorporate the regional projections into a hydrological model and/or collaborate with external partners to assess the consequences in relation to the existing literature.

Estimated cost: R1 317 750
Expected term: 2011 - 2014

The limits of predictability of the South African seasonal climate
University of Cape Town
No. 2067

The research project seeks to determine the limits of the predictability of the South African seasonal climate state and how these limits depend on the season and on ocean and land surface forcing, to determine the robustness of the estimated predictability properties to choice of atmospheric model structure, estimate the contribution of anthropogenic emissions to forecast predictability, estimate the attribution of the risk of extreme weather events to anthropogenic emissions and to characterise the relevance of the limits of predictability in the operational forecast setting.

Estimated cost: R1 200 000
Expected term: 2011 - 2014

Programme 2: Climate change risk, vulnerability and adaptation

The role of local community institutions in the adaptation of rural and urban communities to the impacts of climate change on water access and use
UNISA
No. 1963

This project should focus on the identification and development of existing policy frameworks for examining adaptation practices in the context of rural institutions' role towards livelihood needs. This will be based on analytical approaches that take into account increases in environmental risks, reductions in livelihood opportunities and stresses on existing resources and social institutions. Investigations into likely responses such as migration or mobility, diversification and other adaptation options in light of climate impacts should also be undertaken. The project includes piloting in a rural setting and at urban community levels. The piloting should advise policy discourse on recommended parameters that can reduce these impacts

Estimated cost: R3 000 000
Expected term: 2010 - 2013

Developing water related climate change adaptation options to support implementation of policy and strategies for Water for Growth and Development
University of KwaZulu-Natal
No. 1965

The research is aimed at developing a framework that reflects an integrative adaptive management approach for facilitation of strategies for taking account of vulnerabilities and impacts of climate change in relation to water planning and management. The study will entail analysis of climate change related risks on the development of techniques for integrating long-term climate risks into short- to medium term development of policy decisions and projects. The objective is to develop methodologies for providing support to the Department of Water Affairs in mainstreaming climate change issues into water management as part of the implementation of the Water for Growth and Development strategy.

Estimated cost: R3 000 000
Expected term: 2010 - 2013

Development of decision-support guidelines for vulnerability assessments and adaptation requirements among rural economies and communities, including gender issues (Phase 1)
North-West University
No. 2282

Climate change is already starting to affect some of the poor and most vulnerable communities around the world. The effect that increased droughts, extreme weather events, tropical storms and sea level rises will have on large parts of Africa will be inflicted in our lifetimes. For some rural communities, the consequences could be apocalyptic. These communities have limited access to essential services, and this is also compounded by uneven distribution and overexploitation of water resources. Understanding sensitivities and vulnerabilities of systems and communities is necessary to inform adaptation action. This approach is particularly crucial since communities' resilience varies according to their adaptive capacities to climate change. These

vulnerabilities are not only found in Africa but are a concern worldwide. Various methods and frameworks are available to assess the vulnerability of communities facing various environmental hazards (in this case impacts associated with climate change). These can be applied to the topic of water (both as a problem or a solution) and human security. In such an analysis, the links between the social, ecological and physical systems needs to be addressed and the vulnerability assessment needs to be encapsulated within a wider framework of sustainable development to be policy relevant. This will allow the decision makers to manage the vulnerability of communities and make the necessary adaptations within the larger context of planning and development.

Estimated cost: R700 000
Expected term: 2010 - 2012

Programme 3: Integrated flood and drought management

Improvement of early preparedness and early warning systems for extreme climatic events flood warning
South African Weather Service
No. 2068

Enhancement of the early warning systems of extreme flood events, particularly the SAFFG system, based on in situ observation and remotely-sensed hydro-meteorological information as well as the prediction tool, to support water resource and disaster managers in flash-flood risk evaluation and analyses, river flow forecasting as well as precipitation estimation, is in the aim of this project. Methodologies will include reviewing of international best practices of early warning and preparedness for flash-flood events, and comparison of available technology such as the SAFFG, TOPKAPI and others. Other activities will entail the following:

- Improve rainfall estimation (from radar and satellite) and nowcasting input into the flash flood guidance modelling system
- Improve the hydrological input and products of t-flood guidance warning system, including soil moisture estimation products
- Enhance the integration of system components to enable seamless application of flash-flood warnings down to end-users such as disaster management and water managers

Estimated cost: R813 000
Expected term: 2011 - 2014

NEW PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reform

Natural resource governance system in South Africa
Pegasys Strategy and Development (Pty) Ltd
No. 2161

- To conduct an analysis of the advances made and the challenges being faced in the international arena regarding governance frameworks, and how these inform the local/ national level discourse

- To review the current governance framework (at both policy and implementation levels) highlighting opportunities and constraints in the current institutional, strategic and regulatory frameworks for sustainably managing water resources
- To explore the priority issues highlighted in the document, 'Current and emerging governance systems in terms of water governance' (Ref 1514/1/06), which require further elaboration
- To review and update the above-mentioned Water Research Commission (WRC) document
- To recommend strategies and action plans on enhancing the knowledge base and addressing current challenges to improve and ensure good water governance
- To conduct information-sharing sessions and workshops to build capacity as well as create an aligned understanding of the governance framework and its implementation

Estimated cost: R1 000 000
Expected term: 2012 - 2014

Programme 5: Future scenarios

Insights towards an improved governance model and practical implementation of rural development and community upliftment projects, centred around the productive use of water
Pegasys Strategy and Development (Pty) Ltd
No. 2166

- To conduct information sharing sessions and workshops to build capacity as well as create an aligned understanding of the governance framework and its implementation
- To generate an understanding of the challenges and problems that these communities face in terms of using water productively
- To map out the difficulties that Government departments have faced in terms of supporting community upliftment projects linked to water and productive use, as well current plans for future support
- To develop an overarching governance framework and guidelines to assist Government in providing the necessary support to communities

Estimated cost: R580 000
Expected term: 2012 - 2014

An analysis of paradigms shaping water research in South Africa: questions for future research
University of Cape Town
No. 2170

- Identify, deliberate and evaluate research questions currently being asked by researchers active in the water sector in South Africa in relation to medium- and long-term future considerations
- Identify, deliberate and evaluate research questions currently being asked by researchers active in the water sector in South Africa in relation to medium- and long-term future considerations

Estimated cost: R300 000
Expected term: 2012 - 2014

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

WRF rainfall parameterisation and verification
EScience Associates (Pty) Ltd
No. 2162

The aims of this project are to:

- Determine the best parameterisation and model set-up for WRF in terms of modelling rainfall
- Install rain gauge network for model verification in case study areas
- Input WRF into a hydrological model and verify against stream discharge measurements
- Forecast rain events based on parameterisation in the first aim

Estimated cost: R748 651
Expected term: 2012 - 2014

A methodology to create a South African river network with hydraulic intelligence
ARC (Institute for Soil, Climate and Water)
No. 2164

The aim of this project is to develop a semi-automatic methodology to create a robust, co-extensive (countrywide) and accurate river network coverage for use in GIS projects and other planning initiatives.

Estimated cost: R1 000 000
Expected term: 2012 - 2015

Programme 2: Surface water / groundwater hydrology

Favourable zone identification for groundwater development: Options analysis for local municipalities
Metago Water Geosciences (Pty) Ltd
No. 2158

The aims of this project are to:

- Mainly, develop a methodology and atlas of favourable target zones for groundwater development for priority municipal areas
- Prioritise areas based on aquifer characteristics and socio-economic factors
- Develop indicators for groundwater options analysis
- Delineate and map the potential target zones (based on desktop analyses and fieldwork)
- Prioritise the target zones based on aquifer yield, infrastructure costs and treatment costs
- Develop conceptual models for all the selected sites
- Develop protection zone strategies for the selected target zones
- Repackaging of existing management plans for local municipalities
- Identify new or improved research and educational opportunities

Estimated cost: R2 000 000
Expected term: 2012 - 2014

Programme 3: Water resource planning

Update of water resources of South Africa (WR2005): Phase 1
SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2143

Estimated cost: R4 000 000
Expected term: 2012 - 2016

The aims of this project are to:

- Critically evaluate the outcomes of the WR2005 study in terms of uses, users, impact and knowledge gaps
- Enhance the groundwater data and provide a review of catchments where groundwater is a significant resource
- Incorporate the WRC unified assessment of groundwater methodology
- Develop a folder system based on WMA of all major land uses that have impact on water availability
- Develop simulated, present-day analyses of key gauges (of the order of 100) throughout the country
- Develop a web-based database for WR2012 study for the purpose of national water resource planning which can be continually updated
- Enhance the WRSM2000 model to suit user requirements; develop the Pitman daily time-step and daily calibration facility
- Provide extended training to 8 universities and 2-week training to the Department of Water Affairs on WR2012 and the WRSM2000 model thereby enhancing the user-support system for WR2012 products
- Recommend the optimal monitoring requirements and strategic monitoring points for South Africa in respect of rainfall, streamflow gauging, groundwater and water quality for the efficient assessment of the country's water resources
- Develop a rating system for quaternary catchments that will give users a measure of the confidence they should have in using naturalised and simulated streamflow in that quaternary catchment. Climate change sensitivity analysis.

Estimated cost: R400 000
Expected term: 2012 - 2015

Non-parametric multi-site stochastic rainfall generation including climate change-related nonstationarity
University of the Witwatersrand
No. 2148

The aim of this project is to develop an efficient and effective nonparametric multi-site monthly stochastic rainfall generator that incorporates non-stationarity due to climate change/variability.

Estimated cost: R417 600
Expected term: 2012 - 2014

Implementation of a South African National Standard for Water Retaining Structures
University of Stellenbosch
No. 2154

The overall aim of this project is to provide the South African engineering community with their own South African standard for the design of water retaining structures, by supporting the development of this standard up to the stage of a voted SABS committee draft (CD), which is ready to be converted by SABS into a Draft South African Standard (DSS) for public comment and subsequent publication through normal SABS procedures as a National Standard (SANS). The standard will take account of local conditions and materials and be calibrated to our corresponding loading code SANS10160:2010 and concrete design code SANS10100-1/SANS EN 1992-1-1.

Estimated cost: R790 000
Expected term: 2012 - 2015

Evaluation of the monthly stochastic rainfall generator in existing Department of Water Affairs risk-based water resources yield assessment processes
Hydrosol
No. 2155

This project aims to:

- Undertake an independent evaluation of the monthly stochastic rainfall generator
- Assess the impact of migrating from the application of monthly stochastic stream flow to monthly stochastic rainfall in water resources yield calculations for various climatic zones
- Quantify and explain the differences in yield results obtained from the two alternative methods
- Undertake a cost-benefit analysis of the full scale implementation of the stochastic rainfall methodology in DWA water resources planning studies
- Develop and communicate recommendations on the process and the way forward with DWA and other stakeholders

Estimated cost: R700 000
Expected term: 2012 - 2014

Integrated water use quantification methodology for South Africa
University of KwaZulu-Natal
No. 2205

The aims of this project are to:

- Critically assess approaches and methodologies of quantifying water use directly and indirectly and carefully assess the accuracy levels of these methods
- Integrate appropriate sources of data, information and methodologies into a single internally-consistent water use quantification and accounting system
- Apply the system to assess sectoral water use and all components of the hydrological cycle in selected study areas in South Africa
- Using available observed/measured and simulated fluxes of the components of the hydrological cycle, assess the impact of errors on the water balance, quantify the uncertainties associated with poor and/or unavailable data

Estimated cost: R2 500 000
Expected term: 2012 - 2013

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Presence, levels, and potential implications of HIV anti-retrovirals in drinking, treated, and natural waters
North-West University
No. 2144

The aims of this project are:

- To conduct a literature survey on HIV-ARV presence in the environment. A first screening shows no reports whatsoever. The literature review will therefore expand to generic pharmaceuticals as well as other ARVs.
- To determine the major HIV-ARV compounds used in SA. This will be done in collaboration with role players such as the pharmaceutical industry and Departments of Health. If there are too many compounds of concern, we will select a cross-section based on modes of action.
- To develop extraction and analytical procedures for selected HIV-ARVs from water and fish. We will use our newly-acquired HPLC-MS for this purpose, as well as extraction equipment used in other WRC projects looking at POPs.
- To collect treated wastewater from four different wastewater treatment works, at least three rivers, and at least three impoundments. The localities will be determined after the literature survey and in consultation with the project reference group.

Estimated cost: R471 000
Expected term: 2012 - 2015

Surveillance of viral, faecal indicator bacteria and *Vibrio* pathogens in the final effluents of wastewater treatment facilities in the Eastern Cape Province: a vehicle for capacity development in microbial water quality science in the Province
University of Fort Hare
No. 2145

The aims of this project are:

- To carry out a survey of existing wastewater treatment facilities in the entire Eastern Cape Province, noting their dates of establishment, working capacity and current statuses
- To assess the occurrence and distribution of human viral pathogens and faecal indicator bacteria and their pathogenic strains in the selected wastewater treatment plant effluents
- To assess the occurrence, distribution and antibiogram characteristics of *Vibrio* bacteria pathogens and faecal indicator bacteria including their pathogenic and toxic strains (*E. coli* and *Enterococcus*) in the selected wastewater treatment plant effluents
- To determine the physico-chemical qualities of the selected wastewater treatment plant effluents
- To correlate viral and bacterial pathogen occurrence with seasons and the physicochemical qualities of the selected wastewater treatment plant effluents

- To compare data obtained from typical urban, semi-urban and rural communities of the seven main districts and metro's that make up the province
- To submit a report of these findings to the WRC and Eastern Cape Provincial Government

Estimated cost: R900 000
Expected term: 2012 - 2014

Encouraging citizens' water quality management through subcatchment forums
Mvula Trust
No. 2151

The aims of this project are:

- To bring together existing literature on catchment forums in South Africa that is relevant to dealing with water quality issues in a comprehensive overview
- To survey and understand the workings of existing catchment forums, and the factors influencing their sustainability, inclusivity, effectiveness and legitimacy
- To develop recommendations and guidelines for the functioning of catchment forums that are sustainable, inclusive, legitimate and effective
- To discuss the findings and recommendations with stakeholders involved in catchment forums
- To test the guidelines by piloting them in selected forums

Estimated cost: R600 000
Expected term: 2012 - 2014

Screening study to determine the distribution of common brominated flame retardants in water systems in Gauteng
Tshwane University of Technology
No. 2153

The aims of this project are to:

- Characterize exposure to BFRs using common aquatic organisms found within the water systems
- Investigate seasonal trends of those BFRs found within the water systems
- Develop an environmental contamination profile of landfills, surface water, wetlands, groundwater, sediment, landfill and biota within the study area with respect to BFRs
- Employ derivatisation techniques to develop a treatment kit that can be used to analyse high molecular weight BFRs
- Attempt to identify the sources of BFRs if found present in relation to land use

Estimated cost: R900 000
Expected term: 2012 - 2016

Investigating the occurrence and survival of *Vibrio cholerae* in surface water sources in KwaZulu-Natal Province of South Africa
University of Johannesburg
No. 2168

The aims of this project are:

- Detection of *V. cholerae* using optimised culture-based real-time PCR method

- Detection of *V. cholerae* using culture-independent real-time PCR method
- Implementation of an internal process control to monitor the performance of *V. cholerae* real-time PCR assays
- Using the newly validated methods, determine the occurrence and distribution of *V. cholerae* from zooplankton, phytoplankton, amoeba, animal stools, sediments and water from rivers in KwaZulu-Natal Province

Estimated cost: R555 000
Expected term: 2012 - 2014

Programme 2: Water Quality modelling

Using an integrated water quality management model to support the implementation of National Water Act water use authorisations
Golder Associates Africa (Pty) Ltd
No. 2159

The aims of this project are:

- To use the refined model developed and to demonstrate how it can support the implementation of integrated water use licences and other water use authorisations, by setting up management units with the relevant stakeholders such as water use licence holders and catchment stakeholders
- To produce a web-based system that will ultimately link to existing tools such as WMS and eWQMS, the stakeholder database and geographical areas, and be available for use by other water users at various levels
- To present the system at a minimum of two relevant conferences over the proposed two years of the project.

Estimated cost: R555 000
Expected term: 2012 - 2015

Programme 3: Impacts on and of water quality

Microbial pathogens in water resource sediments: their dynamics, risks and management
CSIR
No. 2169

The aims of this project are to:

- Characterise and model the pathogen loads from point, non-point and land use practices in two selected areas (this will be undertaken in close cooperation with WRC project K5/1984)
- Develop simulation model/s based on the outcome of the hypothetical models and the processes that drive the remobilisation of pathogens from sediments to ultimately predict pathogen loads under different climatic conditions (above- and below-normal rainfall events) and seasons (dry versus wet) of the year
- Develop a tool that links derived turbidity measurements obtained from remote sensing data with microbial contamination levels under different climatic conditions
- Use the Basins-4 framework to make the models' availability and outcomes standardised within the research community
- Build capacity in relevant stakeholders with regard to the use of the developed models to improve decision making

Estimated cost: R1 300 000
Expected term: 2012 - 2015

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Water sources protection

Development of an interactive vulnerability map and preliminary screening level monitoring protocol to assess the potential environmental impact of hydraulic fracturing
University of the Free State
No. 2149

The aims of this project are to:

- Carry out a background review in order to understand the issues related to hydraulic fracturing and to identify possible risks to the resources (biodiversity and water) of South Africa.
- Produce an interactive map that should mainly assist in aiding decision-makers in determining whether hydraulic fracturing should be allowed in certain sensitive areas of South Africa
- Develop a provisional screening-level monitoring protocol for a typical hydraulic fracturing site (this protocol should be applied by the regulators to regulate hydraulic fracturing and should monitor, with minimal costs, whether hydraulic fracturing has major potential impacts on any sites where hydraulic fracturing might be allowed and implemented

Estimated cost: R900 000
Expected term: 2012 - 2014

Hydrogeological heritage overview: Upper and Lower Fountains, Pretoria, City of Tshwane
University of Pretoria
No. 2150

The aims of this project are to:

- Acknowledge the Upper and Lower Fountain in Pretoria, City of Tshwane Municipality, as a heritage site forming part of South Africa's diverse cultural history
- Acknowledge the importance of this site in the history of South Africa and subsequently the need to create awareness at all levels (local resident, education and scientific) to preserve not only the history of the fountains, but also to ensure public understanding and awareness in future
- Embark on such a public awareness campaign for the selected site, aiming to capture the history of the site and to elaborate on the scientific workings for public awareness
- Address available data (if available) for brief interpolation of historical trends and to address the importance of protection of water sources (e.g. Groenkloof Nature Reserve as the protection zone; also including surface water resources)
- Evaluate the water resources heritage and history of the City of Tshwane with the emphasis on Pretoria and its groundwater resources
- Supply the products in electronic brochures, booklets and/or posters for educators, municipalities, leisure and heritage sites, and the scientific fraternity

Estimated cost: R100 000
Expected term: 2012 - 2013

The selection and validation of sediment toxicity test methods to be included in the National Toxicity Monitoring Programme
Golder Associates Research Laboratory
No. 2160

The aims of this project are:

- To conduct an extensive survey on national and international toxicity methods utilised as well as new methods to evaluate sediment contamination
- To test and validate the sediment toxicity tests using the in-house cultures according to international methodologies
- To test and validate available sediment toxicity test kits available in order to identify the most cost- and time-effective methods to screen sediment samples
- To provide final method and validation documentation
- Training and implementation of the method

Estimated cost: R1 715 150
Expected term: 2012 - 2015

The economics of sustainable aquifer ecosystem services: a guideline for the comprehensive valuation of aquifers and groundwater
Prime Africa Consultants
No. 2165

The aims of this project are to:

- Develop a framework and methodology for groundwater valuation for different hydrogeological settings
- Define and demonstrate the role of aquifers as an ecosystem asset, using the Millennium Ecosystem Assessment framework
- Develop an alternative economic approach to the planning and management of groundwater resources, and develop this into a guideline for the comprehensive valuation of aquifers and groundwater
- Develop an updated estimate of the value of the groundwater economy of South Africa

Estimated cost: R827 350
Expected term: 2012 - 2014

Groundwater remediation technologies manual for South Africa – a theoretical treatise and practical guide
Hydro Aqua Earth
No. 2167

The aims of this project are as follows:

- The principal aim or objective of this proposed project is to provide a source of reference documentation for improved knowledge on technologies to remediate contaminated groundwater for the use of stakeholders
- Subsidiary objective 1 – to provide guidelines for characterisation of sites of groundwater contamination

- Subsidiary objective 2 – to provide a compilation of an inventory of available technologies for the remediation of contaminated groundwater
- Subsidiary objective 3 – to provide technical manuals relating to specific technologies that apply to the field of groundwater remediation (including the scientific basis, processes involved, and design systems)
- Subsidiary objective 4 – to develop guidelines for choosing appropriate and effective technologies for the remediation of contaminated groundwater, taking into account the particular contaminant (or contaminant mix), and the geological and biophysical environment of the impacted site or location

Estimated cost: R1 000 000
Expected term: 2012 - 2015

Programme 2: Land-water linkages

The effect of long-term fire frequency and season treatments on the soil hydraulic properties and soil water balance within semi-arid savannas in the Kruger National Park
SANParks
No. 2146

The aims of this project are as follows:

- The key question of this research is to understand the long-term effects of fire frequency, season and intensity on the soil hydraulic properties and the consequent impacts on the soil water balance on two different soil geologies in the Kruger National Park
- To determine the effect of long-term fire and no-fire treatments within basalt and granite geologies on soil hydraulic properties and soil water balance. In order to determine the variation of this effect across these geologies, as a result of a decrease in soil surface crusting and water repellency associated with fire
- To determine the effect of long-term fire regime on the soil hydraulic properties, in order to determine if an increase in fire frequency, season and intensity may alter those soil hydraulic properties associated with infiltration and redistribution across the two geologies

Estimated cost: R320 000
Expected term: 2012 - 2014

Groundwater yield-reliability analysis and operating rules for rural areas
University of Venda
No. 2157

The aims of this project are:

- To review literature on existing methods for yield-reliability analysis and deriving operating rules
- To select and delineate a water-scarce rural area on a fractured aquifer with no groundwater yield time series data as a groundwater resource unit (GRU)
- To monitor soil moisture, groundwater abstractions and groundwater yield, and compute runoff for the GRU
- To compute groundwater recharge for the GRU
- To assess groundwater resource availability for the GRU

- To perform yield-reliability analysis and derive groundwater supply operating rules for the case study village
- To generalise the groundwater operating rules for rural areas with fractured aquifers in South Africa

Estimated cost: R700 000
Expected term: 2012 - 2015

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Investigating climate change effects under altered land uses on water yield and downstream ecosystem services
Golder Associates Africa (Pty) Ltd
No. 2156

The aims of this project are:

- To investigate the impacts of invasive plant species and degraded land on hydrological responses, particularly on sustained water yields, under present and projected future climatic conditions through the refinement of hydrological modelling methods at appropriately fine spatial scales
- To investigate the effects of projected climate changes on downstream ecosystem services and their economic values, and ascertain how these could affect human wellbeing and the resilience of natural systems
- To develop a strategy and guideline for adaptive catchment management towards improved water yield, based on the modelling results

Estimated cost: R900 000
Expected term: 2012 - 2015

Stratospheric and tropospheric radiative forcing of Southern African climate variability and change
CSIR
No. 2163

The aims of this project are:

- To test if the inclusion of realistically varying GHG as well as stratospheric sulphur dioxide and ozone concentrations in an AGCM will improve on seasonal forecasts of rainfall and temperature over Southern Africa
- To quantify the improvement in terms of season (spring, summer, autumn and winter), variable (rainfall and temperatures) and lead-time (up to 6 months' lead)
- To investigate to what extent stratospheric ozone depletion interacts with the enhanced greenhouse effect to impact on Southern African circulation and rainfall patterns
- To investigate the circulation dynamics by which the effects of stratospheric cooling are communicated to the subtropics, and Southern Africa in particular
- To obtain plausible projections of how ozone recovery and increased greenhouse gas concentrations will interact over the coming century to cause climate change over Southern Africa

Estimated cost: R1 008 100
Expected term: 2012 - 2015

Programme 2: Climate change risk, vulnerability and adaption

Pinpointing human infectious disease risks and climate vulnerability: An integrative approach using cholera as a model
CSIR
No. 2147

The aims of this project are:

- To develop an early warning system for waterborne infectious disease outbreaks using *Vibrio cholerae* as a model organism
- To delineate areas and populations at risk under future climate scenarios
- To develop risk maps indicating the possible extent of infectious disease outbreaks under different climate scenarios
- To develop a generic guidebook for adaptive management and preparedness
- To demonstrate water use, access, storage and collection technology adaptation on a small scale in one area

Estimated cost: R1 500 000
Expected term: 2012 - 2015

Planning for adaptation: Applying scientific climate change projections to local social realities
Umphilo waManzi
No. 2152

The aims of this project are:

- To develop and test a process of translating scientific climate and hydrological model output into community accessible, local-level scenarios of future climate and water resources to allow for community-led development of adaptation strategies
- To understand socio-political and institutional issues that arise at the community level in planning for climate change and water resource adaptation with local communities
- To pilot, test, and improve an approach and methods, for application to other catchment areas in South Africa
- To engage national Government and water resource stakeholders in dialogue about climate change and water resource adaptation at the local level

Estimated cost: R1 100 000
Expected term: 2012 - 2015

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KSA 2: WATER-LINKED ECOSYSTEMS

STANLEY LIPHADZI | EXECUTIVE MANAGER

KSA 2: WATER-LINKED ECOSYSTEMS

SCOPE

The glossary of the Environmental Health Centre of the National Safety Council defines an ecosystem as: "the interacting synergism of all living organisms in a particular environment; every plant, insect, aquatic animal, bird, or land species that forms a complex web of interdependency". An action taken at any level in the food chain, use of a pesticide for example, has a potential domino effect on every other occupant of that system. Note that the term 'all living organisms' does include people.

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river), groundwater and water table-dependent (dependent on a water table, but not on surface water). This KSA continues to focus on the protection and sustainable utilisation and management of the aquatic environment and biota (instream, 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 by rural communities).

In the light of local needs and international trends in research, the portfolio of research by which the scope of this KSA is addressed will be adjusted when deemed necessary. However, the primary objective remains 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, taking into consideration demographic dynamics and threats due to climate change, alien and invasive species.

KSA 2: WATER-LINKED ECOSYSTEMS

OBJECTIVES

Although the scope of the KSA has room for further growth to accommodate more thrusts and programmes, the primary and secondary objectives of this KSA are still relevant to address future research need scenarios appropriately. 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 services from water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

This is achieved through the following (secondary) objectives which aim to:

- Develop an understanding of the ecological processes underlying the delivery of goods and services
- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems
- Transfer the knowledge to appropriate end-users through the development of innovative tools and methods for effective knowledge dissemination. These will be developed in conjunction with other KSAs within the WRC.
- Strategically align research with the WRC mandate and Government outcomes and other priorities
- Promote good science and build capacity in both research and management to sustainably manage aquatic ecosystems.

THRUSTS AND PROGRAMMES

The research portfolio for 2012/13 was organised within the following thrusts:

- Thrust 1: Ecosystem processes
- Thrust 2: Ecosystem management and utilisation
- Thrust 3: Ecosystem rehabilitation

The scope of the strategic thrusts and programmes within KSA 2 is 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 that informs policy and management.

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 and 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. Support will be provided in building the capacity to implement the research findings.

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 DWA.
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 sustainably. This programme is managed in close association with Marine and Coastal Management, DEA.
Programme 3: Ecosystem health	Scope: The River Health Programme (RHP: custodians are DWA, WRC and DEA) 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. As such the programme covers all water resource types, hence the inclusive name of: National Aquatic Ecosystem Health Monitoring Programme is used, with RHP focusing only on rivers. This programme links to the WRC impact area of Water and Society 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 WRC impact area Water and Society.
Programme 5: Endocrine disrupting compounds	Scope: The overall objective is to characterise, and acquire information for assessing, the endocrine-disrupting 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 three phases, of which the first phase 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 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. Support will be provided in building the capacity to implement the research findings.

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 DEA and DWA. 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 and impoundment rehabilitation	Scope: The research conducted within this programme aims to provide protocols for the rehabilitation of rivers and impoundments, with the emphasis on urban rivers and the impoundments that they feed, 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.

BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed funding budget of R14 274 007. The consolidated research project budget is presented below:

Research portfolio	Approved 2012/13 (R)
Current projects	6 751 408
New projects	6 619 100
Additional 2011 transfer	903 499
Total	14 274 007

CORE STRATEGY

Healthy people depend on a healthy environment. This is particularly true in the case of the peri-urban and 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 dependent 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, 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 varies from individual, for example, fibre for mat- and basket-weaving or medicinal benefits, to universal, such as good quality water for abstraction and urban use and intact wetlands to aid in improvement of water quality and flood attenuation. In short, society cannot survive without the underpinning support from the environment.

The core strategy is fundamentally aligned to the WRC's mandate, with focus given to development of innovations that will address changing and expanding needs of society. The research funded within this KSA aims to address national initiatives and priorities such as Presidential priorities (Government MTEF), National Planning Commission priorities, and Government outcomes, and the three legs of sustainability (society, economy, and environment) as defined by the 2002 Johannesburg Summit and the National Water Resource Strategy, Water for Growth and Development, the requirements of legislation and international conventions (e.g. biodiversity conservation planning – Convention on Biological Diversity, and wetland integrity – Ramsar) of South Africa. The development of capacity for both research and implementation will receive special attention in the next five years.

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 not only provides knowledge for the protection of the resource and the biodiversity of aquatic ecosystems, but also supports sustainable utilisation of aquatic resources while ensuring equity between generations. The KSA strengthens the notion of promoting ecosystems as

natural water infrastructures and shared resources that should be valued by everyone. The KSA research further addresses the commitment to international conventions, the needs and implementation of policy as well as sustaining the capability of the environment to support the flow of benefits on which society depends. Various aspects of climate change (including adaptation and mitigation) are addressed by the KSA and this entails developing an understanding of the impact of global warming (water temperature) on aquatic biodiversity (ecosystems). This knowledge will enable societies (especially rural, poor people) depending on goods and services from the environment to improve their resilience to climate change.

The position of the WRC in funding research on ecosystems

The aquatic ecosystem comprises the resource and is a legitimate water user in terms of the National Water Act of 1998. Aside from this legal protection, aquatic ecosystems 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.

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 understand ecosystem processes and ensuring that the knowledge generated supports sustainable management and utilisation of aquatic resources. Sustainable management of the aquatic resources includes rehabilitation of the degraded resources with the aim of restoring process, form and function of the aquatic ecosystems. Knowledge gained through the KSA's research is utilised to guide the direction of future resource management and planning, which supports Government legislation and other initiatives.

It is anticipated that sustainable management of ecosystems and their support of livelihoods 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.

Links to Government Outcomes

Research on water-linked ecosystems enables good environmental governance and ensures that water is managed in a sustainable manner that protects ecosystems from the adverse impacts of demographic and climate change. The research creates an understanding of the ecological processes underlying the delivery of goods and services, and provides knowledge and expertise to sustainably manage, protect and utilise aquatic ecosystems. Over the medium-term, the WRC will develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems. This research portfolio contributes in the delivery of mainly two Government outcomes, which are, 'Environmental assets and natural resources that are well protected and continually enhanced' (Outcome 10), and 'Vibrant, equitable and sustainable rural communities and food security for all' (Outcome 7). Specific outputs for each outcome, which are relevant to the scope of this KSA, are addressed within the mandate of the WRC.

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources

In support of this output, the WRC continues to support ongoing studies about evaluating the potential contribution of toxicity data to environmental water quality management in South Africa, as well as those on endocrine-

disrupting compounds. The KSA continued to support a project on potential ecological and human health risks posed by persistent organic pollutants in aquatic ecosystems in a densely industrialised and urbanised area, as well as a study of the interactive endocrine disruptor effects of pesticide mixtures in water on selected species, and a study on developing sediment/toxicity guidelines, in support of this output.

Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/ atmospheric quality

To contribute to the body of knowledge on climate change and to assist in developing adaptive strategies, the WRC has completed a project that has produced a locally-made version of a miniature water-temperature logger. Long-term water temperature data are and will be required to model and manage challenges related to climate change. A new research project began in April 2012 on biological temperature thresholds for the ecological Reserve, with a particular focus on climate change and adaptation.

Output 3: Sustainable environmental management

The WRC will continue to enhance and promote our understanding, as a country, of the use of endemic biota for biomonitoring the health and integrity of water resources in South Africa. The WRC has an ongoing project on aquatic microbial diversity assessment of water resources in South Africa, which started in 2011, and aims to develop approaches that will be used to assess the health and functioning of estuarine ecosystems. This will be important to enhance the protection and sustainable management of estuaries.

Output 4: Protected biodiversity

The WRC continued supporting a project on the assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park and the physical and chemical factors affecting their distribution. In collaboration with DWA, DEA and SANParks, the WRC supported a research study on biomonitoring of the fish health of two impoundments on the Olifants River, Limpopo Province. This study supports efforts to determine the cause of crocodile deaths that have been reported in the Kruger National Park and other areas. The death of crocodiles is seen as an indication of the greater threat that aquatic biodiversity and ecosystems are exposed to in rivers and other water resources. A new WRC research project to address the conservation needs of crocodiles began in April 2012. A suite of ecological, physiological, epidemiological and genetic data will be collected to expand current understanding of crocodilian biology and facilitate long-term protection of this species. Various other projects on control and management of alien and invasive species continued to be supported.

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all.
Output 2: Improved access to affordable and diverse food

Most of the projects in this KSA contribute to ensuring that people have access water, food and natural medicines that are not contaminated. Most of the KSA 2 projects promote environmentally-friendly land-use practices, protection of water resources and aquatic life, and assessment of water quality, which bring about access to food (fish and vegetables) as well as natural medicines that are free from contaminants (enhancing water and food security). For example, the WRC has ongoing projects on: the management or prevention of non-point source pollution from different land uses to protect water resources and ecosystems, and a study on interactive effects of pesticide mixtures in water on selected species.

Output 4: Improved employment opportunities and promotion of economic livelihoods

The WRC continues to ensure that postgraduate and post-doctoral students are part of the project research teams or are employed to work on WRC projects. Although the employment, like research projects, is for less than four years, this is a good opportunity for most students who intend to pursue academic or consulting careers. Moreover, poor students are able to earn some form of a living. Employment within WRC projects also improves working opportunities of the involved students because they gain work experience and skills that the academic and consulting institutions require.

Needs analysis

This KSA closely supports the implementation of Government legislation and initiatives. The KSA translates the Government Outcomes into expressed needs that are addressed by the research portfolio.

The KSA continued to direct effort into introducing and promoting ecosystem knowledge to local government institutions, especially SALGA and LAB, portraying ecosystems as natural (water) infrastructure that provides humans with different benefits such as flood control and improvement of water quality and quantity. Moreover, the KSA aims to address specific needs that promote and support sustainable management and protection of water resources and associated biodiversity. 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 reflected yet as needs in South Africa. There is also a need for repackaging of both the existing and new knowledge that will help in water management, training and public awareness. 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 KSA continues to support research that addresses the longer-term needs of the country. Funding research to contribute to the capability to sustainably manage ecosystems is an overarching need which this KSA continues to address. In addition, involving both the decision makers and the community in the above is key to the successful implementation of the research findings.

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 past decade and a half, we are reaching the limits of current knowledge. In recognition of this, the KSA has begun more research initiatives 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 and the goods and services that they provide to people. The contributions and roles that aquatic ecosystems play in rural communities are enhanced by this KSA through rehabilitation and restoration programmes such as Adopt-a-River, Working for Water and Working for Wetlands. These national programmes also make an immense contribution to supporting job creation and water security. The KSA, in collaboration with DWA and DEA, continues to pay special attention to the effectiveness and efficiency of RDM methods and tools, particularly those used in the Reserve determination, with the intention to meet the needs of users and beneficiaries.

Overview of technological trends

Positioning of ecosystems as important resources and infrastructure

Research studies that develop and advance knowledge in this field are supported to enable the country to take advantage and gain benefits from its diverse natural resources. Healthy ecosystems play significant roles as natural infrastructure or capital. Some countries have begun to include natural ecosystems in cities' development plans as part of the infrastructure that supports and supplies goods and services to communities. The KSA will support efforts to position ecosystems as a resilient infrastructure that South Africans can depend on for the delivery of some of the essential goods and services such as clean water, natural medicines, flood control, etc. The WRC, through this KSA, will continue to be innovative in promoting sustainable socio-economic development through research. The WRC actively seeks partnerships with all stakeholders to develop appropriate local-based innovations. Effort is made to engage social scientists in order to bridge the gap between research and society to create viable socio-ecological systems.

Ecosystems and sustainable cities

The KSA continues to work with municipalities such as eThekwini to create and implement knowledge that will enhance the ecological integrity of the landscape and water resources within and around the cities. There is need to improve degrading urban ecosystems to the benefit of all city dwellers. Improved healthy urban ecosystems are valuable recreational and educational resources, sources of water, medicinal plants, fruits and vegetables that poor and peri-urban communities can use. In collaboration with other stakeholders, the WRC will try to address issues relating to how urban and peri-urban ecosystems and biodiversity can be utilized and rehabilitated in an innovative manner to reduce vulnerability in cities and promote natural capital and resilience. Cities can also start generating many ecosystem services while at the same time reducing pollution footprints. Close relationships with municipalities and SALGA ensure that the research output from the WRC is effectively implemented.

Monitoring and assessment of eco-health

Long-term data, tools, methods, and expertise are needed to establish and support programmes aimed at protecting water resources and biota and to enhance sustainable development in the country. The conflict between water resource protection and socio-economic development should be abated. The KSA supports

initiatives that protect and ensure sustainable utilization of water resources. The WRC works closely with DWA, DEA and other stakeholders to ensure that appropriate tools and approaches are developed for South African conditions, to monitor and assess the ecological health integrity of our estuaries, rivers, wetlands, lakes and groundwater ecosystems. A new research study on the methods and indicators needed to feed into the wetland monitoring network was begun in 2012/13. The study will result in the wetland national monitoring programme, a subset of the National Aquatic Ecosystem Health Monitoring Programme, which encompasses the River Health Programme, and the ecological integrity of estuarine and groundwater systems. With the exception of groundwater, all of these programmes are already in operation or being designed by DWA and, in some cases, in collaboration with SANBI and DEA.The WRC, through this KSA, will continue to support the process to develop a National Environmental Impact Assessment Management Strategy that gives effect to the objectives of integrated environmental management as contained in Section 23 of NEMA, within the context of the principles of sustainable development (Section 2 of NEMA).

Ecosystem goods and services

The KSA encourages studies that develop tools and methods of advancing payment for ecosystem goods and services. The KSA has already completed two research studies on ecosystem goods and services, and appropriate methodologies and tools will be tested and refined in coming years. Appropriate approaches designed and adapted in an African context will be pursued. Healthy ecosystems play critical roles in enhancing value in the ecotourism industry. Tourists prefer destinations that present a healthy environment with ecosystems that provides sufficient goods and services such as clean water, air, and food. More knowledge is needed in profiling and understanding the key factors/drivers in different potential areas in South Africa to build on the outputs from a project on National Freshwater Ecosystem Priority Areas (NFEPA) that was completed and published in 2011/12. Developing this sector in poor rural areas can boost the economy and job creation in those areas.

Eco-terrorism and biosecurity

Eco-terrorism can be explained as an act of terrorism intended to damage another's natural environment. The country and the region have experienced ongoing destruction and degradation of critical endemic ecosystems and biodiversity. The degradation has mainly been as a result of pollution, and excessive abstraction and harvesting of natural resources. The WRC, through this KSA, continues to support studies that determine the sociological, economic and ecological impacts of this man-made destruction (ecoterrorism). The actual costs of environmental degradation are greater than what can be imagined. Eco-terrorism can be a bio-safety matter that affects community health and national food safety.

Global change and sustainability

The implementation of the Global Environment Facility (GEF) presents research funding opportunities for WRC projects addressing biodiversity. The KSA has established studies and activities that support the country's effort to adapt to climate change in consideration of the needs of local communities that are vulnerable to the adverse effects of climate change. Based on the Government outcomes, stakeholders' and the Board's views, the KSA continues to improve knowledge of the socio-economic aspects of sustainable ecosystem management. This requires increased effort toward enhancing knowledge about quality and quantity of water resources, biodiversity protection, and mitigation

and adaptation to climate change, while at the same time using the knowledge to support rural communities and food security.

Water quality
Nationally, water quality continues to deteriorate and is a priority area (Government Outcome 10, Output 1). As such, the WRC, through this KSA, continued to support studies and efforts aimed at improving this situation. The KSA has realised that research focused on the complexity and management of this problem is needed, and a solicited study began in 2012/13 to investigate what has been done on this subject in South Africa and globally so that future research studies can be aimed at addressing the most critical areas or gaps.

Ecosystem health and environmental water quality
Knowledge of ecosystem health and environmental water quality provides the basis for balancing the use and sustainability of the resource. This research is a topical subject. The impact of deteriorating water quality, as shown by fish and crocodile deaths in the Olifants River, Kruger National Park, and anticipated acid mine drainage have drawn the attention of researchers and water managers to this field of research. The KSA will continue to support studies, in the foreseeable future, aimed at increasing understanding of the response of ecosystems to changing habitats and water quality.

Environmental water requirements (quantity)
Research studies initiated by the WRC on Reserve determination for non-perennial rivers are providing new understanding in the dynamics of rivers in the environment. Perennial rivers are largely limited to the well-watered east and the main stems in the arid west of South Africa. However, many of the tributaries, even in the well-watered east, are non-perennial.

Biomonitoring of water resources
The WRC, with DWA, DEA and SANBI, supports, through research, the development of biomonitoring tools and methods for rivers and wetlands. Tools that support the River Health Programme such as the South African Scoring System (SASS) have proved to be efficient and useful in the determination of the ecological integrity of rivers. To support implementation, the WRC has developed videos on the use of SASS as a biomonitoring tool. These videos were distributed to biomonitoring practitioners, schools and communities in 2012/13. The WRC has also supported the investigation of the potential of using diatoms as an indicator for wetland health.

Management of biodiversity
Research into the management of biodiversity (in terms of the recent legislation and Output 4 of Government Outcome 10) will continue to grow in the next few years and the current WRC research supports the country's initiatives on protection and sustainable use of our biodiversity and ecosystems. Besides numerous research projects related to sustainable utilisation of biodiversity, such as for wetlands, the KSA continues to support research about developing methods for control of alien and invasive fish from selected rivers. A research study on control of alien fish species began in 2011 in the Western Cape, and is developing effective methods of restoring river ecosystems that are degraded by alien invasive fish species. Alien and invasive species remain some of the top threats to biodiversity. The WRC, through this KSA, continues to collaborate with CAPE Nature, DEA, SANBI, NRF, SAEON and SAIAB in supporting this initiative and promoting public awareness.

Ecosystem governance
Ecosystem governance has been identified as an essential component of sustainable management, as shown by the failure of some research programmes to achieve the results that the technology developed during these programmes promised. To this end greater emphasis is being placed on ensuring that this aspect is addressed during research, in order to provide technologies for implementation. Current ongoing research, for instance, the Shared Rivers project, will enrich the understanding regarding the above.

Key stakeholders

The key stakeholders remained largely unchanged in 2012/13. In addition to the Department of Water Affairs (DWA) and Department of Environmental Affairs (DEA), other Government departments such as Agriculture, Forestry and Fisheries (DAFF), Science and Technology (DST), and Rural Development and Land Reform (DRDLR), are of importance. Provincial and local government form another group of stakeholders, and the needs of the catchment management agencies (CMAs) which are currently being established influence research direction. Other end-users of the research are water boards, and rural communities and others living off the land.

Research providers
The major providers of new knowledge in the field covered by this KSA are researchers at the universities (Limpopo, Venda, North-West, Witwatersrand, Johannesburg, Free State, Zululand, KwaZulu-Natal, Fort Hare, Rhodes, Nelson Mandela Metropolitan, Stellenbosch, Walter Sisulu, Western Cape and Cape Town), science councils (in this field predominantly the CSIR and the ARC) and within various consultancy firms. Efforts will continuously be made to build research capacity of historically-disadvantaged individuals, especially at the academic institutions.

Within the abovementioned universities, the researchers are housed within specific research institutes or other units focused on specific aspects of research. The consultant firms which do work in the field of ecological research and management normally focus on the more applied aspects for rapid implementation. This is a good way of rapidly implementing research results and getting feedback into the research process at the same time.

RESEARCH PORTFOLIO FOR 2012/13

This KSA focuses on the protection and sustainable utilisation of the aquatic ecosystems (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. More effort is being put into addressing land use impact and terrestrial ecosystem change that has an impact on water resources and aquatic ecosystems. It addresses national research needs (strategically of long- medium- and shorter-terms) as well as those of international conventions on environmental management (e.g. wetland conservation (Ramsar) and the Convention on Biodiversity). Work done within this KSA continues to contribute in the reviews of the National Water Act (NWA of 1998), strategies 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 has also addressed some of the immediate research needs related to the NWA and its implementation.

In essence, the implementation plan for 2012/13 has followed 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.

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

The relationship between periphyton, flow and nutrient status in Western Cape foothill rivers and the implications for management
University of Cape Town (Zoology Department); National Institute of Water and Atmospheric Research (NIWA); Nelson Mandela Metropolitan University
No. 1676

To address the objectives of the study, a quantitative assessment of the physico-chemical and biological conditions that potentially drive periphyton dynamics in the foothills of south-western Cape rivers was conducted. Temporal changes in abiotic and biotic factors under natural flow and nutrient conditions were studied over 21 months (October 2007 to May 2009) and these were compared with the patterns under altered flow conditions and nutrient enrichment. This study showed clear seasonal cycles in environmental conditions in the Berg and Molenaars Rivers that are typical of rivers in Mediterranean climates elsewhere. Temporal shifts in temperature and solar irradiation were used to define six seasons over an annual cycle, namely, winter, early spring, late spring, summer, early autumn and late autumn. The study managed to address natural seasonal changes in periphyton biomass and community composition in the foothills of south-western Cape rivers, and the effects of enrichment and flow alteration. The factors or combination of factors, (i.e. hydrodynamics, temperature, light, grazing, habitat and water quality) which explain differences in periphyton communities under natural and altered conditions were studied further to identify their relative importance. Moreover, the differences in periphyton communities in biotopes typical of foothills in south-western Cape rivers were explored for different nutrient conditions and seasons. Periphyton communities with different pre-flood growth forms were compared in terms of their response to individual flood events of different magnitude. Recovery of a periphyton community following a flood was also monitored. This report constitutes the first detailed assessment of periphyton community structure and biomass in South African rivers. It explains how periphyton responds to flow regimes and nutrient enrichment, and reveals the importance of understanding periphyton dynamics in water resources management. It contributes to the body of knowledge that should be used in determinations of the ecological Reserve and can help guide future monitoring of aquatic ecosystem health.

Cost: R1 000 000
Term: 2006 - 2012

An assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park and the physical and chemical factors affecting their distribution
Bioassets cc; University of Venda; SANParks; University of Johannesburg
No. 1928

The study was conducted based on 45 sites, representative of the ecoregions of the Kruger National Park (KNP). The sites were selected to cover as much vegetation, geological and habitat types as possible. All 45 sites were surveyed in summer, while 14 of them (being rivers) were surveyed in winter as well. Sampling was done twice a year at all summer sites. As part of the frog diversity survey, frogs and tadpoles were physically collected and night surveys conducted. During the night surveys, calls were recorded and frogs crossing roads were collected. Where water was present a water sample was collected and in-situ water parameters measured. Sediment samples to use for sediment classification and chemical analyses were collected from all the sites. Historic surveys in KNP resulted in 33 frog species being recorded. During the current survey 30 frog species were recorded. A combination of historic and recent field surveys resulted in 34 frog species being recorded from KNP. The results of this survey indicate that long-term monitoring projects specifically focused on amphibians are required within the KNP pan systems. The water quality tests, including for acid rain, as well as histopathological tests, revealed no conclusive results, though some organs (kidney, liver, etc.) showed pollution impacts in some frog species.

Cost: R1 037 500
Term: 2009 - 2012

Biomonitoring the fish health of two impoundments in Olifants River, Limpopo Province
University of Limpopo; University of Venda
No. 1929

The water quality between the two impoundments was shown to be significantly different, but the water chemistry parameters were more important in driving the differences, rather than the metal concentrations. The metal content in the sediments of Flag Boshielo Dam are significantly higher than those of the Phalaborwa Barrage, with iron and aluminium contributing more than 99% to the dissimilarity between the two impoundments. The study found that there is a significant difference in metal concentrations in the muscle tissue of fish from the two impoundments. Considering each impoundment, a significant difference in the metal concentrations in muscle tissue was found for Flag Boshielo Dam. A significant, but weak, relationship was identified for both dams, the metal concentration of the muscle tissue and that of both the water and the sediment. The fish populations from both dams seem to be in overall good health. Further, the HAI indicated that the four fish species were in relatively good health at both dams. The study contributes to establishing the zoogeographical ranges and reduces the information deficit for some parasites. For instance, the monogeneans of most fish species, especially cichlids, are not well documented in South Africa. The *Enterogyrus* sp. from the stomach of *O. mossambicus* is a new species and record for South Africa. *Paradiplozoon* sp. recorded from the gills of *L. rosae* and *Gyrodactylus* sp. from the gills of *C. gariepinus* are new locality records and possible new species. One digenean parasite found in the orbit of *L. rosae* is a new host and locality record for South Africa (and possibly a new species). The *Ergasilus* sp. recorded from three different hosts is a new species as well as new host and locality records for South Africa. The sixth new species recorded during this study is *Lamproglena* sp. from the gills of *L. rosae*. None of the parasites identified from the hosts from both dams reached alarming infection levels. These parasites reached such intensity levels without affecting the host condition, thought to be an adaptation that probably ensures that the larvae survive to reach the final host without killing the

intermediate host. Fish health (including parasite burden) is important as freshwater fish are consumed by humans on a regular basis, especially in rural areas. The digenean larvae, including *Clinostomum*, *Euclinostomum* and possible the digenean cysts from the gills and muscle, are of zoonotic importance and these larvae have the potential to develop in humans. Overall, though the fish health was good, parasitic infection rates were high. The risk to human life through consumption was determined and needs to be communicated clearly.

Cost: R674 500
Term: 2009 - 2012

Programme 3: Wetland processes

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
Dames; University of Waterloo
No. 1857

The effects of changes in climate or landscape on wetland ecosystems need to be considered within the context of natural processes. Hydrological processes are a key component in the development and maintenance of wetlands and the source of water determines a wetland's vulnerability to a changing landscape and environment. The overall objective of the proposed research was to investigate the ecosystem processes that regulate water supply in the St Lucia wetland complex, with specific reference to the Mfabeni Peatland. The specific objectives were:

- To construct a rigorous water balance on the Mfabeni Peatland-coastal dune complex
- Quantify the nature, magnitude and persistence of water efflux to the estuarine system
- Evaluate the potential effects of changing climate and land use practices, especially plantations, on the water dynamics of the system.

Wetlands, including peatlands, in general, and coastal peatland swamp forests in particular, are being threatened by various land use changes. These include expanding *Eucalyptus* plantations; subsistence- and commercial-scale cultivation practices in and around the iSimangaliso Wetland Park and infrastructure development such as roads and tourism-related activities (e.g. lodges, boardwalks and trails). A set of general and specific guidelines were drafted to support sustainable management of peatlands in Maputaland. These guidelines will need another round of workshopping with interested parties, such as DAFF, iSimangaliso Wetland Authority, KZN Wildlife and local plantation owners and farmers, in order to validate them, to establish ownership and institute a sound cooperative management framework for involved roleplayers. Conservation management of these ecologically sensitive areas needs to take cognisance of the sensitive nature of these ecosystems and at the same time incorporate sensible land-use practices to accommodate the socio-economic needs of impoverished communities depending on these ecosystems for survival.

Cost: R859 750
Term: 2008 - 2012

Establishing ranges of water quality variables in wetlands and their relationship to land use and ecosystem response: towards refining the ecological Reserve
University of Cape Town (Freshwater Research Unit); Department of Water Affairs; North-West University (Potchefstroom Campus)
No. 1921

As soon as more wetland water quality data have been collected, the boundary values formulated in this project should be refined. It may then be possible to develop boundary values for all five Ecological Categories (A-E) rather than the three levels developed here. The results from this study have shown that there is natural variation in water quality between different wetland types and specifically that depressions have naturally higher levels of constituents than other wetland types. These findings, however, were not taken into account during derivation of this set of guidelines, as it was felt that more investigation is first required. Once this has been done, the boundary values may need to be revisited and different values derived for depressions. Similarly, the results from this study have also shown that water quality varies naturally with region and that pH, and possibly nitrates plus nitrites, are lower in wetlands of the Fynbos biome. More work is required to develop and validate the diaotom assessment index for wetlands.

Cost: R1 070 064
Term: 2009 - 2012

Regional wetland processes of the Maputaland coastal aquifer on the Zululand coastal plain
ARC (Institute for Soil, Climate and Water); University of Waterloo; Ezemvelo KZN Wildlife; iSimangaliso Wetland Park
No. 1923

The interaction of environmental factors and processes on a broad scale, such as climate, geology, geomorphology (including topography) and hydrology, and the influence thereof on wetland distribution and function on the Maputaland Coastal Aquifer (MCP) is poorly understood. Furthermore, it is unclear how land-use and the inter-annual variation in seasons affect the extent and distribution of wetlands on the MCP. Land-use activities such as agriculture, forestry and water supply schemes on the MCP and prolonged periods of drought have led to reduced availability of groundwater. The local communities on the MCP depend on the wetlands for their daily livelihood and during drought periods the above-mentioned factors intensify, leading to degraded or vulnerable wetland ecosystems. There is a need to determine spatial and temporal changes in the distribution and function of these wetlands and to understand the controlling processes. The following research questions need to be addressed:

- What types of wetlands are found on the MCP?
- What factors control their distribution?
- What are the impacts on the MCP wetlands?
- How should MCP wetland types be managed?

The aim of this project was to understand the regional processes that control the different wetland types and their distribution on the Maputaland Coastal Aquifer in north-eastern KwaZulu-Natal. The primary focus of the study was to classify wetlands on the Maputaland Coastal Plain; characterise the relationships between hydrogeomorphic setting (climate, geology, geomorphology and hydrology) and the nature and distribution of wetland types; and land-use/land-cover changes caused by climatic variability and land-use changes in recent decades.In South Africa the potential evapotranspiration exceeds precipitation (primarily

rainfall). Wetlands in these conditions are often dependent on groundwater as the key driver. Rainfall provides the main recharge to the aquifer. The rainfall amount and variability are influenced by synoptic processes including frontal winter systems, convectional thunderstorms and significant cyclonic rainfall events, and relatively infrequent rainfall events associated with advancing moist air from the Indian Ocean crossing the MCP. The freshwater recharge to Lake St. Lucia on the MCP is highly variable. Seasonal rainfall patterns as well as year-to-year variation in rainfall have a significant impact on water levels of isolated wetlands. However, rainfall interception and replenishment of soil moisture limit recharge to those rainfall events exceeding 10 mm. The results indicate that the Walkley-Black method is the most suitable to measure soil organic carbon in order to determine the hydroperiod for the delineation and classification of permanent, seasonal and temporal wetlands on sandy coastal aquifers. Should cost not be a factor, the dry combustion method can be considered as an alternative. This study contributed in understanding the relationship of a wetland to its water table and how this relates to the HGM type and landscape position. Not only were wetland patterns established in wet and dry years, but the link with the environmental factors that influence the wetland processes was also determined. The different wetland types in the landscape clearly relate to depth and fluctuation of the water table. The results can help to emphasise the function and vulnerability of wetlands based on the inter-annual variability and seasonal/extreme events that could help guide sustainable agricultural practices associated with them. The process driver on the MCP is rainfall coupled with the geological and geomorphological template of the area.

Cost: R893 364
Term: 2009 - 2012

Evapotranspiration from the Nkazana Swamp Forest and the Mfabeni Mire
CSIR (Natural Resources and the Environment, Pietermaritzburg); University of Waterloo
No. 1926

The health and future conservation of Lake St. Lucia is strongly dependent on the water level and salinity of the water within the lake, which is controlled in part by freshwater inflows. During droughts, the rivers to the west (Mkuze, Mzinene, Hluhluwe and Nyalazi) provide limited inflow into the lake. Freshwater seepage from the groundwater mound of the Embomveni ridge on the Eastern Shores area into the Nkanzana and Tewate Rivers, as well as other seepage zones along the shoreline, become the most important contribution to the lake. This groundwater seepage from the Eastern Shores area has significant ecological importance and provides refuge sites where localised freshwater inflows enable many species to survive during periods of high salinity, preventing extinction and loss of biodiversity. For improved management of the system, accurate water-balance studies were required but were impossible without reliable estimates of ET. The solution was to apply the most appropriate and up-to-date methods to determine the long-term ET for this key strategic wetland and to use these results to verify existing meteorologically-based models for future use. This would not only reduce uncertainty in the water-balance study of the Mfabeni Mire, but also provide guidance in terms of seasonal ET rates over wetlands and lead to an improved understanding of the processes that define how the surface energy balance in wetlands is partitioned. This study clearly showed the invaluable contribution that can be gained from field-based measurements. Prior to this study, there was no ET information for the five dominant landscapes of the Eastern Shores area, which is now provided in this report. This will certainly assist in the future management

of the iSimangaliso Wetland Park water resources to ensure the sustainability of the invaluable ecosystem. It was also shown that the different vegetation types have significantly different water use. This implies that changes in land use brought about by climate change or management of the system (by fire for example) will impact the water-balance of the area. The implications of land-use and climate change should therefore be a consideration in the management plans of the area.

Cost: R908 000
Term: 2009 - 2012

Identifying relationships between soil processes and biodiversity to improve restoration of riparian ecotones invaded by invasive acacias
University of Stellenbosch; University of the Western Cape; SANBI
No. 1927

The results of this study support the hypothesis that invasion by *Acacia* species has an impact on soil and microbial processes, and also that these processes can recover when invaders are cleared. The results find key application in the Working for Water Programme, in that removal of *Acacia* species may assist in restoration of riparian ecotones. While plant structure and diversity have not been studied to a great extent in this research, aspects of function that received attention suggest a trajectory back towards the natural state after removal of *Acacia* species. However, more than seven years after removal of *Acacia* species, legacy effects still remain, and these legacies (e.g. high available N) need to be carefully considered in managing clearing and follow-up activities.

Cost: R1 800 200
Term: 2009 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Application and testing of a strategic adaptive management system for freshwater protection, associated with implementation of South Africa's national water policy
SANParks Scientific Services; Fluvius Environmental Consultants; South African Environmental Observation Network (SAEON); University of the Witwatersrand
No. 1797

Water resource management is becoming complex, requiring an adaptive, learning-by-doing approach, and the rivers of the Kruger National Park (KNP) are no exception. This research aimed to consolidate Strategic Adaptive Management (SAM) process, widely used in SANParks, for freshwater management in the KNP, focusing on the flow component of the ecological Reserve. The Rapid-Response-System developed during this work consisted of the defining of 'worry levels', each of which requires defined actions and a management log detailing actions taken and their outcomes, information essential for the evaluation phase of the SAM model, enabling refinement of the model over time. Outcomes of the project include detailed documentation of TPC development, application, assessment and refinement occurring within the KNP river SAM system over the past decade and in particular over the project period, 2008 – 2011. A number of feedback processes, an important component of SAM, are described in the case studies of the Crocodile (East) and Groot Letaba. Future research needs are detailed.

Cost: R1 355 725
Term: 2008 - 2012

Decision support software development for integrated flow assessments
Southern Waters Ecological Research and Consulting; Beuster, Clarke and Associates; AJ Greyling; Water Matters
No. 1873

DRIFT is a process that was developed in South Africa to aid management and future planning of water-resource developments, rehabilitation of rivers or any other management activity that could affect the flow or inundation patterns of an inland water ecosystem. Development has taken place through extensive application of the process within South Africa, in southern and eastern Africa, and on other continents, mostly Asia and South America. The overall process contains three main steps:

1. Set up
2. Knowledge capture, comprising:
   a. Hydrological modelling of present day, naturalised and possible future daily flow regimes (scenarios)
   b. Predictions of the response of relevant physical, chemical, biological and socio-economic variables to described changes in the future scenario flow regimes
   c. Predictions of the economic implications of the scenarios
3. Analysis

The DRIFT Decision Support System (DSS) holds the input data for Steps 1 and 2b, makes the predictions in Step 2c and receives data from outside on Step 2a (the hydrological modelling). It provides the information upon which the outside economic analysis is based (Step 2c) and brings all the information together for the summary reports (Step 3).

Cost: 1 800 000
Term: 2009 - 2013

Review and update of resource directed measures (RDM) for estuaries
Anchor Environmental; Coastal Research Unit of Zululand; Consortium for Estuarine Research & Management; University of Stellenbosch; CSIR; Marine and Estuarine Research; Nelson Mandela Metropolitan University; independant consultant; South African Association for Marine Biological Research (SAAMBR); SA Institute for Aquatic Biodiversity. Southern Waters Ecological Research and Consulting
No. 1930

The National Water Act of 1998 requires the implementation of Resource Directed Measures (RDM) in order to make optimal use of our countrys water resources while minimising ecological damage. The main focus of RDM is the determination of the Reserve, which is the water quality and quantity required for the protection of basic human needs and aquatic systems. The latter component, or ecological Reserve, is the quality and quantity of water required to maintain a desired level of structure and function, or quality, of a specific aquatic system (e.g. river reach, wetland, estuary). The desired quality of the water resource will be defined by its Ecological Category which can be A, B, C or D on a health scale of A to F (Table 1.1). While scientists are allowed to make recommendations for this category, the Recommended Ecological Category; (REC), the final decision will be based on ecological, social and economic criteria in a participative process called the National Water Resource Classification System's Classification Process (Dollar et al., 2010; gazetted in 2010). The Department of Water Affairs is responsible for the classification of all significant water resources in the country, including estuaries, and these

decisions will be re-evaluated at intervals. Although the Classification Process was gazetted only recently, the Reserve determination methods were devised in 1999 (DWAF, 1999) and have been in use since then, though having evolved over time following increased experience and understanding of the methods in practice. This method will continue to the part of the more formalised Classification Process. In the Reserve determination process for estuaries, the method involves (a) estimating the present health status of an estuary, (b) setting an REC on the basis of this and its importance using a simple set of rules, (c) setting an EC based on the ecological, social and economic criteria, (d) predicting how health changes under a range of flow scenarios, and then (e) finding the flow scenario that most closely matches the REC in order to define the ecological Reserve. The Estuary Health Index (EHI) is central to the Reserve determination method.

Cost: R604 400
Term: 2009 - 2012

Linking of daily and monthly hydrological time series for use in monthly water resources models in support of the determination of ecological water requirements
IWR Water Resource (Pty) Ltd; Association for Water and Rural Development (AWARD); University of KwaZulu-Natal (Pietermaritzburg)
No. 1979

Water resources model development and model application within South Africa has focused on monthly time step models, probably because monthly hydrology has been readily available through ongoing research initiatives, commencing with the Hydrological Research Unit in the 1970s. Also, a considerable amount of additional effort is required to expand modelling to a daily time step, without necessarily adding any value, hence the reluctance of practitioners to move towards daily modelling. However, ecologists involved in determining the ecological water requirements of rivers and estuaries are increasingly requesting estimates of flood frequencies and magnitudes from hydrologists and water resource modellers. While daily hydrology models are available in South Africa (for example, the ACRU (Smithers and Schulze, 1995) model), these models have seldom (if ever) been used in ecological water requirement studies, while development on the monthly water resource models to support ecological studies is ongoing. There is clearly a need to address the concerns of ecologists relating to floods and short-duration events. One way of doing this is to integrate the daily times series produced by a daily hydrology model (e.g. ACRU) with a monthly water resources model (such as the Water Resources Modelling Platform (Mallory et al, 2011)). While efforts have been made in earlier studies to generate daily flows in ungauged locations using different sources of information, including monthly flow data, this has been seen as a challenging and non-trivial scientific issue (Smakhtin and Hughes, 1996; Smakhtin, 2000). This project has developed a methodology to disaggregate monthly time series into daily time series using ACRU (Smithers and Schulze, 1995) daily hydrology to provide the daily variability while maintaining the statistical signature of the original monthly time series. The method has been tested on four pilot catchments. The four selected catchments are:

- Sabie: This catchment was selected due to the interest shown by SANParks in daily modelling of the Sabie River catchment as part of ongoing ecological studies
- Upper Breede: This catchment was requested due to the formation of the Breede Catchment Management Agency

- Mokolo: This catchment was requested by riverine ecologist following on from a recently completed ecological study using monthly flows
- Seekoei: This catchment was selected due to its ephemeral nature in order to test the methodology on ephemeral rivers.

While the goal of this project is to produce plausible daily time series, the purpose of the pilot studies is to evaluate these time series and assess whether they meet various statistical criteria.

Cost: R378 000
Term: 2010 - 2012

Programme 2: Estuary management

The application of choice modelling techniques to guide the management of estuaries in South Africa – case studies at the at the Sundays, Kromme, Nahoon and Gonubie River Estuaries
Nelson Mandela Metropolitan University
No. 1924

The primary aim of this project was to generate information that assists managers towards making efficient choices on matters identified to be of current demand interest. This goal was pursued by setting up focus groups of people and experts with interest in and knowledge of selected estuaries, and tasking them to identify and select strategies and investment/operational options on behalf of society – with the goal of improving the recreational appeal of these estuaries. The selected estuaries were the Sundays, Kromme, Nahoon and Gonubie River estuaries. For all the above-mentioned options (specific to each estuary), marginal willingness-to-pay (WTP) values were calculated by applying the Choice Experiment (CE) method. The calculation is made from estimates of choice models. Three different choice model specifications were estimated for these estuaries: a conditional logit (CL) model; a heteroscedastic extreme value (HEV) model, and a random parameters logit (RPL) model. In the case of the Sundays River Estuary, the results from the RPL, HEV and CL models revealed that recreational users were willing to pay more for an estuary management strategy which enabled higher physical size of the fish stock; lowered the amount of boat congestion; and improved the amount of public access available. In the case of the Kromme River Estuary, the results from the RPL, HEV and CL models revealed that recreational users were willing to pay more for an estuary management strategy which enabled higher levels of navigability; reduced the amount of boat congestion; and lowered the amount of access for jet ski and wet bikes. In the case of the Nahoon and Gonubie Estuaries, the results of the RPL, HEV and CL models revealed that recreational users were willing to pay additional rates for improved water safety, protection from criminal activity and support services. However, tests for multi-collinearity were positive, indicating the possibility that orthogonality of the experimental design was compromised. For this reason, no conclusions for management intervention were drawn on the basis of these results. Demonstration of the application of the method to guide management interventions, was therefore restricted to the examples of the Sundays and the Kromme Estuaries. The particular management advice generated and reported above, for the Sundays and the Kromme Estuaries, cannot be extrapolated to all other estuaries because the situations of each estuary differ.

Cost: R770 000
Term: 2009 - 2012

Programme 5: Endocrine disrupting compounds

Development of a Sampling Guide, Volume 2, of the Manual of Guidelines for the Management of EDCs in water resources
Golder Associates Africa (Pty) Ltd; Department of Water Affairs and Forestry; University of Pretoria
No. 1983

The aims of this project were to develop a guide to correct sampling and sample preparation in the context of endocrine disrupting chemicals (EDCs). This project also produced the overall introductory chapter for the current series of EDC management volumes (of which the sampling guide is one). The sampling guide provides an overview of the issues that should be considered when designing a sampling programme (i.e., the how, when, and where). The guide addresses four media, namely, water, sediment, air and biota (typically fish). Quality assurance and quality control are described. Sampling procedures are described for each of the four media. These include pre-field preparation, sampling site selection, actual sample collection, as well as sample storage and transport. The introductory volume advocates a precautionary approach to EDC management. It notes the importance of concepts such as 'duty of care' and reduction of EDCs at source as much as this is possible. It also provides 10 useful one-page 'Fact Sheets' addressing frequently asked questions.

Cost: R495 000
Term: 2011 - 2012

Programme 6: Socio-economic considerations

Establishing the fishery potential of the Nandoni Dam in the Luvuvhu River, Limpopo Province
University of Venda; University of the Free State; University of Limpopo; BioAssets Consultants
No. 1925

This project has shown that over the period of sampling the numbers of fish had declined and this can be ascribed to the uncontrolled harvesting that is taking place. Over and above quotas in the form of harvested biomass being important, the correct use of the correct fishing gear is cardinal. The results of this project indicate the selectivity of the nets used. It is proposed that net selectivity is applied in such a way that no harm is done to the population structure of the target species. This will ensure that a viable breeding population will be maintained. Water quality issues should also be addressed as a matter of urgency. The results of this project have shown that pollution in the Dzindi and Mvudi river catchment existed and that this was reflected by the decline of water quality at the inflow. It is however important to take cognizance of the fact that this decline will extend throughout the dam if no action is taken. It is therefore imperative that water quality monitoring, and plans for corrective actions, should form part of any management plan.

Cost: R773 200
Term: 2009 - 2012

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Long-term response of specific wetlands to Working for Wetlands rehabilitation
Ground-Truth cc; University of KwaZulu-Natal (Pietermaritzburg)
No. 2035

Assessment of the long-term response of two wetlands, Killarney and Kruisfontein, to Working for Wetlands rehabilitation is seen as contributing significantly towards the wetland rehabilitation field of practice as it allows one to reflect on challenges. This reflection assists in 'closing the loop', informing future rehabilitation planning, with recommendations documented for wetland rehabilitation implementation, planning, and monitoring and evaluation. In addition to documenting lessons learnt and refining wetland rehabilitation efforts in South Africa, this study introduces two indices to objectively and defensibly utilise vegetation to quantify changes in long-term wetness and habitat quality. This is the first time that these indices have been applied in South Africa, and based on their application in the study it appears that these indices have particular value for measuring wetland ecosystem response to rehabilitation. In addition, the indices are likely to have much broader application, e.g., for wetland delineation and the assessment of current impacts on wetlands. Another finding that emerged was that the objectives of rehabilitation must be very clear and success or failure must be based on whether these objectives were achieved or not; not all wetlands when rehabilitated will be able to provide the same services and goods – the outcome will be site-specific, i.e., differ from one wetland to the next.

Cost: R256 510
Term: 2011 - 2012

Programme 2: River and impoundment rehabilitation

Food-web manipulation Phase II: Food-web interactions in South African reservoirs traced using stable isotopes
DH Environmental Consulting; Koekemoer Aquatic Services; Muller Environmental; Rhodes University; SA Institute for Aquatic Biodiversity
No. 1918

This research project examined the food web structure of the Rietvlei Dam in order to determine the possibilities for fishery biomanipulation as a tool for attenuating the impacts of eutrophication. This concept presumes that the phytoplankton comprises species that are edible by zooplankton, and that the fishery comprises obligate zooplanktivorous species. This linear feeding pattern is not always the case, especially in non-natural water bodies, such as impoundments. To track the Rietvlei food web, the study employed stable isotope analysis (SIA) techniques for the first time in a South African reservoir. None of the findings gleaned from this study suggested that zooplanktivory has a significant influence on zooplankton community structure and abundance levels. The evidence obtained using SIA indicates that trophic pathways leading to fish primarily follow benthic, rather than planktonic routes. As such caution should be taken in South Africa to assume manipulation of fishery will result in the attenuation of eutrophication.

Cost: R1 500 000
Term: 2009 - 2012

Conservation of tigerfish, *Hydrocynus vittatus*, in the Kruger National Park with the emphasis on establishing the suitability of the water quantity and quality requirements for the Olifants and Luvuvhu Rivers
University of Johannesburg; University of Venda; BioAssets Consultants; SANParks
No. 1922

Tigerfish do respond to the presence of low levels of pollutants. Their highly mobile nature enables them to avoid exposure to debilitating stressors, and, since one of the key criteria for the choice of a bioindicator is that it should represent the ambient conditions, the tigerfish may not be an ideal indicator species for water quality. However, results from the flow assessment done as part of this study clearly showed that tigerfish have very specific flow and habitat requirements, thus making them an excellent indicator species of water quantity. Furthermore, all fish species from the Olifants River have identifiable habitat preferences that were successfully used to evaluate the effects of reduced flows. Low flow discharges of approximately 17 m^3/s in the Olifants River may begin to show higher levels of stress in fish due to reductions in habitat diversity and abundance. Below a flow of 4.9 m^3/s the resulting reduction in flow-dependent habitat types would become severe.

Cost: R1 486 000
Term: 2009 - 2012

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Primary producers as sinks for nitrogen and phosphorus in the Great Brak estuary
Nelson Mandela Metropolitan University (Botany Department)
No. 1982

The study will provide knowledge of the processes that regulate nitrogen and phosphorus cycling in a temporarily open/closed estuary. The previous Great Brak Ecological Water Requirements Study recommended that further studies are needed to determine the loads of nitrogen and phosphorus flowing through the estuary and to determine how effective the estuarine flora, macro-algae and macrophytes, are at trapping and removing these nutrients from the system. Understanding this aspect has become critical in view of the increased water requirements from PetroSA and Mossel Bay and the related decreased inflow to the estuary. Less river inflow to the estuary translates into more closed mouth conditions, which in turn will cause more nuisance algal blooms in the system impacting on both the sense of place and biota of the estuary. The main aims of the study are: to identify the sources and determine the loads of nitrogen and phosphorus entering the estuary, through point-source discharge (e.g. river, sea and storm drains), diffuse discharge (e.g. groundwater seepage from septic tank overflow and golf course irrigation water), atmospheric deposition (rain water) and remineralisation from organic material trapped in the sediment; measure the flux of nutrients between the water column and the benthos; measure the nitrogen and phosphorus content in living plant material; describe the environmental conditions in

the estuary that favour macro-algal blooms; provide recommendations to be included in the Great Brak Estuary Management Plan; and to compare results from the Great Brak Estuary, an estuary dominated by macrophytes and macro-algae, to estuaries dominated by phytoplankton (e.g. the permanently open Sundays Estuary).

Estimated cost: R955 000
Expected term: 2010 - 2013

Programme 2: Riverine processes

Linking hydrology and lateral riparian vegetation zones
Southern Waters Ecological Research & Consulting
No. 1981

The research will focus on standardising the number of lateral riparian vegetation zones, their names and their links to aspects of the flow regime. This has been proposed by Mackenzie et al. (1999) and underlies the recommended data collection approach for riparian vegetation in the Building Block Methodology (Kemper and Boucher, 2008). Possibilities for standardising zone definitions have been explored to some extent in other work done on rivers in the Kruger National Park and also arose out of the previous WRC project (K5/1407), which proposed a biological description of four lateral zones but did not formalise the links with any hydrological data. This initial description requires testing on rivers elsewhere in the country. Therefore, a concise account of lateral zones with consensus on their names and predicted locations; descriptions of their floristic and other attributes, and an assessment of their correlation with flows of different return periods will be invaluable to specialists involved in Reserve determinations, practitioners involved in using VEGRAI under the NAEHP and, importantly, to new entrants to the field of riparian botany. The main objectives of the study are: to identify the number and composition of lateral zones in riparian vegetation communities in a selection of rivers around South Africa; suggest standardised names for the identified lateral vegetation zones; explore the relationships between these lateral vegetation zones and aspects of the daily flow hydrology and, if possible, link the identified zones to flows of particular return periods; and to seek simple methods for the identification of the lateral vegetation zones.

Estimated cost: R1 765 310
Expected term: 2010 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Development of methods for Reserve determination of wetlands. Phase 1: Rapid Reserve
Fluvius Environmental Consultants
No. 1788

While satisfactory methods for determining environmental water requirements in permanent waters exist, wetlands have proved to be more complex. During the dry phase they provide a rich and productive flow of ecosystem services to the terrestrial system (e.g. grazing, agriculture) and during the flooded phase provide an equally important flow of ecosystem services to the aquatic system (e.g. water quality, flood attenuation, fish). The method developed needs to be able to cope with the alternate states of wetlands and their importance to the economies that they serve.

Estimated cost: R1 402 911
Expected term: 2008 - 2009

Environmental water requirements for non-perennial systems: Phase III
University of the Free State
No. 1798

Non-perennial rivers are distinguishable from perennial rivers, in that their hydrology is spatially and temporally much more variable, creating high levels of disturbance for stream communities. Previous WRC research has shown differences in Reserve determination between perennial and non-perennial systems using existing methodology, e.g. the relevance of groundwater in relation to surface water. Furthermore, standard hydrological models cannot predict along the whole hydrological spectrum, from perennial to episodic systems; therefore, water licensing will have to be based on a new understanding or model of the non-perennial hydrology. This study is aimed at testing the prototype methodologies on different river systems.

Estimated cost: R3 000 000
Expected term: 2009 - 2012

Shared Rivers Initiative: Phase II: Analysis of the ecological Reserve implementation scenarios with the intention to design an effective implementation approach/plan
AWARD
No. 1920

There are conflicting views among communities with regard to the use and management of water resources, which has complicated the implementation of trans-boundary water resource management, particularly the ecological Reserve, in RSA. In spite of all the challenges, there are situations where implementation of the ecological Reserve has been successfully executed. There are also situations where implementation has not been successful. Effective planning needs to critique these case studies, to identify the strengths and weaknesses (gaps) of the implementation approaches and methods and the policy itself. The results or output will be used to design 'a new way of doing things' as far as implementation of the Reserve is concerned. The output may also suggest refinement of the policy if need be.

Estimated cost: R800 000
Expected term: 2010 - 2013

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 are 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: R201 160
Expected term: 2005 - 2009

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment

University of Stellenbosch
No. 1712

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.

Estimated cost: R370 000
Expected term: 2007 - 2013

Genetic diversity studies on selected taxa in the Klip River System: Towards the assessment of the usefulness of genetic diversity as an indication of ecological health

Sinelwati Scientific Research & Management
No. 1976

Whilst a lot of progress has been made towards developing various indices for assessing the ecological health of aquatic ecosystems, little is known about the organisation of genetic diversity in wetland and other ecosystems. There has been increased interest in rehabilitation of heavily impacted wetlands and in future this may require reintroduction of various biota. This study will focus on generating basic knowledge needed to strengthen understand of the partitioning of genetic diversity as well as the responses to pollution at the molecular level. The main aims of the research are: to determine levels and patterns of genetic diversity among some biota on the Klip River Wetland and other selected sites; to assess the potential for genetic diversity for use as an indicator of water quality; and to determine correlations, if any, between particular genotypes and physico-chemical properties at selected sites.

Estimated cost: R1 650 000
Expected term: 2010 - 2013

Expanding on a National Wetland Vegetation Database for the purpose of conservation planning, monitoring and wetland rehabilitation

University of the Free State (Plant Sciences, QwaQwa campus)
No. 1980

This is a follow-up of a scoping study (based on three provinces; K8-789) on building a national database on wetland vegetation. It addresses the critical need for baseline data on the biodiversity of South Africa's

wetlands. Furthermore, it will support the Working for Wetlands Programme by establishing a method by which wetland biodiversity can be monitored after rehabilitation. In that sense it will supplement the Wetland Health and Integrity Programme already produced.

Estimated cost: R1 951 000
Expected term: 2010 - 2013

Assessment of locally manufactured radio telemetry equipment for manual and remote behavioural monitoring of fish in lentic and lotic freshwater ecosystems in South Africa
Rivers of Life Aquatic Health Services cc
No. 2111

In this study, a cost-effective, locally-manufactured prototype biotelemetry system, followed by a commercially available model, will be obtained from YRless and tested. These systems will be used to monitor the behaviour of fish in different surface aquatic ecosystems including flowing (lotic) and standing (lentic) water ecosystems in South Africa. Thereafter comparisons between locally manufactured YRless equipment and existing high-cost American Advanced Telemetry Systems equipment will be made and a methodology for the use of cheaper digital radio telemetry systems for the monitoring of fish in South Africa will be developed. There are many advantages of using this technology in monitoring, such as provision of real-time data on temperature, animal activity (e.g. fish), and depth. According to the researchers, more variables can be added to the equipment, such as electrical conductivity, as required. All these water quality variables are key to water resource management, and use organisms in their environment, with minimal disturbance.

Estimated cost: R841 000
Expected term: 2011 - 2013

Programme 4: Environmental water quality

Survey of potential ecological and human health risks posed by persistent organic pollutants in aquatic environments in densely industrialised and urbanised areas
University of KwaZulu-Natal (Chemistry)
No. 1977

A group of contaminants that is receiving ever-increasing attention in water and sediment quality surveys and monitoring programmes in many regions of the world is persistent organic pollutants (POPs). This attention is related to the fact that these compounds and/or their breakdown products are widely acknowledged as a significant health risk (e.g. direct toxicity, endocrine disruptors, carcinogens). Urbanisation is recognised as a far more significant source of contaminants to surface waters compared to agriculture, and surface waters in these areas are often the sole source of drinking and washing water to informal communities. Estuaries are the ultimate sinks for contaminants introduced into upstream waters and hence should provide an integrated understanding of potential problems at the catchment scale. The research has another aim in the context of costs of laboratory analyses and implementing monitoring programmes, namely, to assess whether the monitoring of estuaries (especially those in cities and towns) would be simpler and cheaper than for rivers. The overarching aim of the research is to perform a survey for an extensive suite of persistent organic pollutants in aquatic ecosystems from a highly industrialised and urbanised area and to assess the potential ecological and human health risks of measured concentrations.

Estimated cost: R1 543 176
Expected term: 2010 - 2013

Linking land use and water quality for effective water resource and ecosystem management
CSIR; Ground-Truth cc; University of KwaZulu-Natal
No. 1984

The effect of land use (especially mining and agriculture) on water quality and quantity is of concern and must be given special attention in order to ensure water security for South Africa. There is a need to begin with new ways of managing our water resources to abate water quality challenges that South Africa has been battling with for a long time. The investigation will generate knowledge on the effect of various land-use practices on water quality, sedimentation and river health. The study will have to integrate disciplines such as terrestrial and aquatic resource management. The research should reinforce the principles of IWRM and the importance of catchment management as the ideal way to protect water resources and ensure sustainable utilisation of aquatic ecosystems.

Estimated cost: R1 500 000
Expected term: 2010 - 2013

Aquatic microbial diversity: A sensitive and robust tool for assessing ecosystem health and functioning
Rhodes University (Biochemistry)
No. 2038

The aim of this study is to employ high throughput pyrosequencing of the 16S rRNA genes to characterise estuarine microbial diversity with a view to assessing ecosystem health and functioning in selected estuaries along the Eastern Cape coastline. The intention is to use the data from this pilot study to establish criteria for an early warning system to monitor aquatic ecosystem health based on changes in microbial diversity. The overall objective is to apply this technology in assessing the function and health of both freshwater and marine ecosystems in the future. The project will offer a unique opportunity to characterise the microbial biodiversity in aquatic/estuarine systems.

Estimated cost: R800 000
Expected term: 2011 - 2014

The effects of sediment as a physical water quality variable on macroinvertebrates as input into sediment water quality guidelines development
Rhodes University (Centre for Environmental Water Quality)
No. 2040

The overall aim of this study is to investigate the impact of suspended sediment particles (particulate) as a physical water quality variable on the macro-invertebrates. The project will focus on investigating the impact of suspended sediment particle size and not the bed-load, though the latter is likely to cause more abrasive effects on invertebrates. Utilising the existing data and literature on sediment effects, a generic framework of sediment water quality guidelines will be developed. The microcosm nature of the investigation may need field or experimental mesocosm verification in order to establish a credible and scientific basis for development of sediment water quality guidelines. This project must be conducted hand-in-hand with a sediment bio-toxicity study commissioned by the WRC.

Estimated cost: R1 000 000
Expected term: 2011 - 2013

Programme 5: Endocrine-disrupting compounds in water resources

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 are 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 - 2009

A study of the interactive effects of pesticide mixtures in water on selected species
University of Stellenbosch
No. 1932

Scientific research revealed that all major aquatic wildlife groups are experiencing endocrine disruption (ED) in contaminated sites, and that at many sites this is caused by a complex mixture of substances. Our ability to predict higher-order effects is still weak, and the imperfect state of our knowledge about the effects of EDCs on ecosystem structure has implications for environmental risk assessment of EDCs; therefore ecosystem-based research is much needed. Only in a few cases could a causal link between EDCs in freshwater systems and altered endocrine activity/function in exposed fish or amphibians be established. This study will be a laboratory study to investigate the explicit ED effects of mixtures of at least two pesticides, used in agricultural areas of intensive and concentrated crop-cultivation practices, which could contribute to the ED effects seen in the environment (thus not taking the effects of industrial or other pollution into account).

Estimated cost: R1 600 000
Expected term: 2009 - 2012

Programme 7: Ecosystem governance

The Shared Rivers Initiative Phase 2: Implementation of the Reserve (NWA)
AWARD
No. 1920

Research conducted will develop a dynamic synthesis of the reasons for the lags in the implementation of the National Water Act (NWA) of 1998, focusing on the ecological Reserve. It will not be a blueprint for solving the problem, but it will provide the principles and framework to guide water practitioners and managers in solving context-specific problems. Key to the whole programme is the building of capacity amongst the people involved in all levels of water resource and service management (relevant spheres of government, agriculture, mining, etc.) through action research. A means of working in this study is through collective action, networking, self-organisation and practice-based feedback loops, the aim being to develop these features where they do not already exist. It is anticipated that this will be a collaborative process and some of the outcomes will need to be negotiated. The overall aim

of the Shared Rivers Initiative is to understand and effect change in the implementation of policies and legislation, specifically the ecological Reserve, relevant to the wise use of the Lowveld river systems. In addition, the study will design and implement a series of actions that will build capacity and confidence in the legal competence to enforce obligations associated with environmental water requirements in the region and specifically the ecological Reserve in South Africa. This must be done in such a manner as to allow a generic way of introducing ongoing change which is consistent with adaptive learning.

Estimated cost: R2 500 000
Expected term: 2010 - 2013

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Wetlands and livelihoods: Restoration of wetland ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods
University of KwaZulu-Natal (CEAD)
No. 1986

Wetlands are highly productive and are important for the conservation of biodiversity as well as water resource protection. They are also used by people in both formal and informal (subsistence) agriculture as well as for various forms of recreation. Wetlands are susceptible to alteration through various forms of land use and upstream activities such as water abstraction and mining. Ecosystem goods from wetlands such as fisheries have been shown to be closely correlated to the area flooded, and so knowledge of the environmental water requirements (both quantity and quality) of wetlands is important. Recognising that certain uses impact negatively on the ecosystem goods and services that these wetlands provide, this project aims to define those ecosystem goods and services, to indicate the management activities (including rehabilitation where necessary) required to deliver the goods and services on which various activities (for example: those mentioned above) depend, and to describe interventions for the rehabilitation of impacted wetlands to suit specific uses and users.

Estimated cost: R800 000
Expected term: 2010 - 2012

Programme 2: River and impound rehabilitation

Setting objectives for urban river rehabilitation
Aurecon Group
No. 2036

The ultimate objective of the project is to develop usable tools for both land owners and regulators to assess a wetland and its rehabilitation requirements, and set clear, feasible and practical objectives for rehabilitation. All of this will be combined into a user-friendly guideline document for setting urban river rehabilitation objectives. The research will draw on international best practice examples and contextualise this in the South African situation, using existing and current South African case studies.

Estimated cost: R850 000
Expected term: 2011 - 2013

Hyperspectral remote sensing of water hyacinth: From plant physiology to landscape level changes
University of the Witwatersrand
No. 2037

To have better water hyacinth management, infested sites must be monitored so that the growth trajectory of the weed population is understood, and also to be able to predict what intervention will be required, and by when. This project therefore intends to develop remote sensing as a tool to make predictions; firstly to measure growth and the effects of biological control agents on the weed at a landscape level, and secondly to investigate the impacts of heavy metal water pollutants on biocontrol agents of water hyacinth. Because hyperspectral remote sensing (RS) can detect heavy metals and the effects of insect herbivory on the plants, measurements will be instantaneous and eventually cheaper than laboratory analysis of the plants. Depending on the deployment of the RS sensor, either hand-held or airborne, the weed population can be assessed as a whole, not just as a small sub-sample.

Estimated cost: R610 561
Expected term: 2011 - 2013

Biology, ecology and management of indigenous and invasive alien fish species in the Groot Marico River and Sundays River catchments
Consortium: SA Institute for Aquatic Biodiversity (SAIAB); Golder Associates Africa (Pty) Ltd
No. 2039

The management of invasive fish and conservation of biodiversity is a high priority in the National Environmental Management Act (1998) and the Environmental Management: National Biodiversity Act (2004). In order to effectively conserve the indigenous ichthyofauna and manage the impact of alien invasive fish species an understanding of the distribution, biology, ecology and impact of both the alien and the indigenous fish species in the system is needed. The research will also investigate and assess the role that the water-utilisation infrastructure of the SRIS plays in the ongoing invasion of the Sundays River catchment.

Estimated cost: R1 600 000
Expected term: 2011 - 2013

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

The resilience of South Africa's estuaries to future water resource development based on a provisional ecological classification of these systems
CSIR NRE (Stellenbosch)
No. 2187

Estuaries form the interface between land and sea and are strongly influenced by runoff, sediments, wind, wave action, air and water temperature and constitute some of the most heavily utilised and productive zones on the planet. A coarse, national-scale preliminary health status assessment of South African estuaries has recently been undertaken as part of the National Biodiversity Assessment (NBA) 2011 of the South African National Biodiversity Institute (SANBI). However, the NBA status assessment was based on very limited hydrological information (a key determining factor in the health status of many SA estuaries). While the NBA study did provide a 'desired state' for each estuary based on its

biodiversity importance, it did not reconcile the health status assessment or present ecological state (PES) with reversibility of pressures (identify Best Obtainable State), national biodiversity plans and targets; or strategic economic development plans in order to propose a provisional ecological classification of estuaries, nor did the NBA 2011 address resilience to future water resource development. This project aims to extend and improve the NBA assessment to contribute to the knowledge pool necessary for the incorporation of estuaries in strategic water resource planning as explained above. The output from this study is intended to inform strategic planning processes and is not aimed at the operational management level, where detailed, site-specific studies (e.g. EWR studies) still remain important.

Estimated cost: R1 400 000
Expected term: 2012 - 2015

Programme 2: Riverine processes

Biological temperature thresholds for the ecological Reserve
Freshwater Consulting Group
No. 2182

The refinement of upper thermal limits and the formulation of biological temperature thresholds for incorporation into the water temperature component of the ecological Reserve is considered critical for the protection of aquatic ecosystems. Existing stress on aquatic resources, including both water quantity and quality, is likely to increase in response to demand for water (Dallas and Rivers-Moore, 2009). There will likely be an increase in impacts on water temperature as a result of climate change, hydrological changes (e.g. water abstraction, low flows, river regulation, dams, interbasin water transfers), changes in rainfall patterns, etc. The links between water temperature and flow and flow and ecosystem response are well known. How much change is acceptable to society? Increased thermal stress is likely to lead to homogenisation of freshwater communities, loss of specialist species, and lowered system resilience. As a signatory to the Convention on Biological Diversity, South Africa has an obligation to meet conservation and biodiversity targets. Thermal stress is also likely to exacerbate water quality issues such as increased outbreaks of algal blooms and spread of disease vectors. Such water quality effects have obvious health and economic impacts for society. Understanding of the biological consequences of thermal stress, and incorporation of this stress in the form of biological temperature thresholds, applied within the context of the ecological Reserve, will provide a valuable tool for managing aquatic resources.

Estimated cost: R1 000 000
Expected term: 2012 - 2015

Ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Phongolo River
NWU
No. 2185

Following the construction of the Pongolapoort Dam in 1974, concerns related to the influence of the resulting changes in water flows into the Phongolo floodplain led to extensive studies by Heeg et al. As there is increasing pressure from local communities to access and utilize the ecosystem services of the Ndumo Game Reserve, it has become essential to determine to what degree this conservation area maintains the aquatic biodiversity of the floodplain as whole. In this project the quantity and quality drivers in the Phongolo system will be related to the ecological responses at different levels of biological organisation. The influence of aquatic ecosystem

health will be assessed by determining the ecological status of the Phongolo River and associated floodplain through fish, amphibian and bird community studies. Collectively the knowledge derived from this project can be utilized within specific species conservation plans and broader-scale risk assessments. This will enable the relevant conservation authority, Ezemvelo KZN Wildlife, to meet their mandates to establish conservation plans for the ecologically threatened species in the Phongolo floodplain. These management interventions will make a valuable contribution to the sustainable maintenance of the ecological services of this unique ecosystem that were originally identified in the early studies, i.e. the importance of the floodplain to the society, economy, health and ecosystem in general.

Estimated cost: R2 552 800
Expected term: 2012 - 2015

Connectivity through allochthony: Reciprocal links between adjacent aquatic and terrestrial ecosystems in South Africa
Rhodes University
No. 2186

Central to issues of quality and availability of water is the question of whether organisms (including humans) are under threat due to pollution, food limitation, or over-harvesting in both fresh- and salt-water systems. The dynamics of nutrients in ecosystems is captured in the concept of allochthony, whereby material produced outside a given area is transferred elsewhere, hence providing links between adjacent habitats and communities that established ways of thinking do not routinely consider to be connected. Different forms of nutrients and energy move across the conceptual boundaries of ecosystems via organism activities or physical processes such as wind or water currents, and these transfers can represent important food subsidies. The study is aimed at understanding the trophic connections between adjacent habitats that are usually conceptually partitioned and considered in isolation (land, stream, river, estuary and ocean). Human activities constantly reshape these connections, with consequences for both humans and the natural environment. A key challenge is to create a vehicle through which several different aspects of transfer can be studied concurrently within the same region (at least at the scale of a hydrological catchment), with the ultimate aim towards creating a reliable large-scale flux budget.

Estimated cost: R1 700 000
Expected term: 2012 - 2015

Programme 3: Wetland processes

Biodiversity, conservation and management of Nelson Mandela Bay temporary wetlands
Nelson Mandela Metropolitan University
No. 2181

The unpredictable rainfall makes temporary or ephemeral wetlands more cryptic and difficult to delineate. The combination of broad-scale desktop analyses and fine-scale site level field and laboratory data will bring new understanding of the types of wetlands in this region, their vegetation and aquatic invertebrate communities and biodiversity, including interactions between physical structure and chemical processes. Much needed data about the wetlands of this region will aid in conservation planning, in particular that of the Nelson Mandela Bay (NMB) municipality, which would help protect vulnerable and rare wetland ecosystems and assist in the management of development within in the municipal boundaries. It is, equally, an important test of the new national classification system that will

provide feedback into the NWCS and either support the desktop method for this region or modify the existing system appropriately. Through this research programme not only will the existing tools used in wetland evaluations be tested, but new and critical baseline information on the functioning of these systems will be added. This baseline data will be able to assist in the prioritization of wetlands in the NMB metro for conservation, protection and rehabilitation. This work will help gain insight and improve understanding with regards to mitigating the challenges associated with climate change and important ecological drivers responsible for system alterations.

Estimated cost: R1 600 000
Expected term: 2012 - 2015

Trajectories of change of wetlands in the Fynbos Biome: Part A. Habitat transformation, water quality and diatom response

Freshwater Consulting Group
No. 2183

It is commonly reported in the literature that at least 50% of wetlands in South Africa have been lost and many more seriously degraded and yet it is very difficult to establish the veracity of this statement. Certainly, wetlands appear to be increasingly under threat due to the spread of urban infrastructure and expanding agricultural activities. Seventy-five wetlands in the Western Cape were surveyed between 1987 and 1989. As part of that survey, the wetlands were photographed, water chemistry parameters were measured and plant and invertebrate samples taken. However, the project was prematurely terminated and the biological data has never been published. In this project the Western Cape fynbos wetlands will be revisited to collect further data on biota and physico-chemical aspects, and reporting will be updated to encompass the current ecostatus approach. The framework developed can be adopted and applied anywhere in the country.

Estimated cost: R1 500 000
Expected term: 2012 - 2015

Nile crocodiles in north-eastern KwaZulu-Natal

University of KwaZulu-Natal
No. 2188

The recent die-off of crocodiles in the Kruger National Park (KNP) and at Loskop Dam have revealed the vulnerability of the species and highlighted the need for urgent study of Nile crocodile populations in Southern Africa. The KZN population is second in size only to the Kruger population, and the governing conservation organisation, EKZNW, has the obligation to conserve this important population effectively. As a top predator the Nile crocodile is a valuable ecosystem component but also a source of management concern, as individuals can cause problems when they leave protected areas. If crocodile populations are sick or in decline, it is a serious reflection on the health of their associated water bodies and other organisms in the food web. Mitigation of threats to crocodiles is important for protection of aquatic habitats at an ecosystem level and has a positive trickle-down effect on sympatric aquatic species. Lake St. Lucia and environs represents one of only three major breeding areas for the Nile crocodile in South Africa. Crocodiles require large areas of undisturbed wetland (e.g., Lake St. Lucia) to maintain large, stable populations. As water levels fluctuate, movements of crocodiles within and out of particular areas become ecologically important to individuals and populations. Environmental fluctuations are suspected to affect the demographic stability of crocodile populations because of their direct and indirect influences on recruitment,

mortality and food availability. This project aims to address the aforementioned conservation needs of Nile crocodiles in the study area by gathering sound data on a suite of ecological, physiological, epidemiological and genetic components for the species. Additionally, it aims to analyse the specific threats to crocodiles (human-, environmental- and disease-related) while simultaneously generating novel solutions of risk reduction for both sides of the crocodile-human interface. Information from field and laboratory studies will be used to produce predictive models of population viability and change that are needed to support proper long-term management of Nile crocodile populations in the study area.

Estimated cost: R884 000
Expected term: 2012 - 2015

Identification of wetland processes impacting water resources at catchment scale
CSIR (NRE)
No. 2191

In South Africa wetlands are recognized as fundamental components of catchments as they not only serve to maintain biological diversity but also serve as linkages between aquatic and terrestrial ecosystems. Their important roles include flow regulation, water purification, etc. Wetlands are thus important for management of both water quality and quantity in catchments, but no indicators have been developed for monitoring wetland integrity at this scale; only local wetland-specific indices exist. Besides catchment scale health integrity indicator development, the research will add a dimension of catchment level process-based indicators to wetland delineation as a way of improving wetland delineation in cases where biological and soil-based indicators are insufficient to show boundaries clearly.

Estimated cost: R684 500
Expected term: 2012 - 2015

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 3: Ecosystem health

Consolidation and optimization of wetland health assessment methods through development of a Decision Support Tree (DST) that will provide guidelines
Freshwater Consulting Group
No. 2192

There are currently two main wetland PES assessment methods that are being utilized interchangeably by the wetland assessment practitioners. Some wetland specialists have identified gaps in these methods and have subsequently supplemented the shortcomings by developing other tools. This is creating significant problems in maintaining consistent standards of data collection, reporting and confidence in the assessments and output PES scores and Ecological Categories which are derived. A support system, such as Decision Support Tree (DST), is required by different directorates within DWA and by other regulatory authorities (such as provincial environmental and conservation departments) for more effective and consistent decision-making with regards to the protection of wetlands. This project will deliver products that can support different end-user requirements, such as Reserve determinations, Recommended Ecological Category determinations, monitoring, WULAs, EIAs and rehabilitation plans. In particular, the outcomes of the research will provide a decision support system to assist DWA and other departments in selecting appropriate wetland health assessment techniques for different applications. The

recommendations made regarding improvement of existing tools will also pave the way for improvement of existing methods.

Estimated cost: R300 000
Expected term: 2012 - 2014

Development of a strategic framework for the sustainable management of water resources found within catchments where ESKOM operates, with initial focus on wetlands
Eon Consulting
No. 2222

With the view to facilitating water resource management by ESKOM and Government departments, this project sets out to develop a sustainable environmental planning framework for the conservation (and rehabilitation) of wetlands, within a catchment perspective. In order to develop and test this proposed conservation management approach for wetlands where ESKOM operates 'coal to customer', it is intended to:

- Conduct a situation analysis of methods available to ecologically sustainable energy generation
- Test an adaptable plan at catchment level that can be applied at national level
- Apply and evaluate the environment conservation plan at selected ESKOM sites
- Establish capacity needs for the establishment of monitoring tools and train a core group of implementing / training officers

Estimated cost: R1 000 000
Expected term: 2013 - 2014

Develop and test a landscape-based multidisciplinary and multi-sectoral decision support system to support integrated water resource management in Mpumalanga
SANBI
No. 2281

The impacts of mining are felt by the natural environment as well as many stakeholders. In addition to non-compliance with active mining licensing conditions, there are many abandoned mines that continue decanting mining-impacted water. The pollution load within catchments is aggravated by effluents from non-functional wastewater treatment plants. Mpumalanga, with the largest concentration of coal mines in the country, faces a considerable proportion of these challenges. Coal mining, in particular, poses serious threats to headwaters, wetlands, rivers, dams, groundwater, soil productivity, livestock production, grasslands, biodiversity, air quality, and human health. It is necessary first to determine the extent of water quality issues in Mpumalanga in preparation for integrated resource management. Existing mining licensing processes will be examined, to develop a decision support system (DSS) as well as a monitoring system which will ensure that mining and other land uses (as job creation and poverty alleviation) adhere to sustainable development requirements, while taking into consideration the complexities associated with natural, physical and societal needs. To build the capacity of communities, businesses and government officials, awareness-building and training tools are planned. Finally, proposals will be submitted about the resources required for ongoing implementation of the DSS and monitoring framework.

Estimated cost: R1 000 000
Expected term: 2013 – 2014

Programme 4: Environmental water quality

Critical analysis of water quality in South Africa: historic and current trends
Rhodes University (Institute for Water Research)
No. 2184

South Africa is widely recognised as having an admirable water law, and as being a leader in granting a right to water, in terms of quality and quantity, to the environment. However, the water quality of South African water resources is deteriorating rapidly although good water quality management structures, strategies, approaches, programmes, instruments, and tools have been developed and implemented nationally over the past decade. The question is: Where do the problems lie, and how can we change them? In order to address this question, we need to understand what environmental water quality (EWQ) is. Management of water resources links the complexity of biophysical and ecological systems with the complexity of human social systems. As such, an understanding of how management interventions may impact on the resource requires a transdisciplinary approach in order to holistically incorporate aspects traditionally considered by different disciplines. This approach is reflected in proposals for an integrated approach to water resource management. Several programmes exist in South Africa, monitoring the individual components of EWQ. The integrative EWQ approach is used by water resource managers, for example, for setting and monitoring progress towards appropriate ecospecs (ecosystem requirements), userspecs (water user requirements) and Resource Quality Objectives (RQOs: a combination of ecospecs and userspecs). EWQ is explicitly included in the Reserve, where water in sufficient quantity and of sufficient quality is set aside for basic human needs and for the protection of aquatic ecosystems to secure ecologically sustainable development and use thereof. Furthermore the EWQ approach is used for meeting water licence criteria, for the management of acid mine drainage, and in the Green Drop status compliance for wastewater treatment works. Some of the issues around the decrease of environmental water quality have been attributed to difficulties in meeting goals in water resource management through management practices and institutional and stakeholder cooperation and coordination. The project aims to understand and characterise South African environmental water quality management approaches, instruments and programmes; to characterise the long-term trends of environmental water quality in South Africa. This will require analysing the historic and current state of environmental water quality; to identify shortcomings in environmental water quality management approaches, instruments and programmes by correlating these with trends in environmental water quality; and to make specific recommendations in the form of developing future research priorities.

Estimated cost: R300 000
Expected term: 2012 - 2014

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

The classification of endorheic wetlands (pans) and the effect of acid mine drainage on the hatching success of the egg banks of selected invertebrates communities within pans
University of Johannesburg
No. 2190

With many of the endorheic wetlands (pans) in South Africa occurring in areas where there has been an increase in mining activities, it has not been unexpected

that the number of environmental impact assessment (EIA) and monitoring programmes has also increased. As many of these systems are already (or will in the future) be affected by mining activities, the effect of AMD on the biota is also of particular concern, especially at Ramsar sites. The effect of AMD on the hatching success of egg banks has not been well studied, especially in South Africa. This study will thus contribute to our knowledge of the effect of water quality changes in particular on the branchiopod communities within these systems. This is very important as these branchiopod crustaceans are specifically adapted to these endorheic ecosystems. Many branchiopods (especially Anostraca) are also classified as being endangered or threatened according to the IUCN Red List. A dormant egg phase is a dominant feature of most large branchiopod taxa. After production, eggs are deposited on the substrate ultimately forming egg banks. The conditions required to end this dormant stage vary between species and can even vary amongst a population of the same species. As a result, a population of a particular species of branchiopod can often consist of different generations. Some may have hatched from eggs that were deposited the previous season while others can be from eggs that were deposited a decade ago (or more). Studies have shown that the metals alone can have an effect on the hatching success of dormant egg stages. Changes in water quality may thus influence the hatching success of these branchiopods and, with conductivity and pH having a major influence on hatching, AMD may lead to a loss in the biodiversity of branchiopod crustaceans.

Estimated cost: R684 500
Expected term: 2011 - 2015

Development of a methodology to determine the appropriate buffer zone width and type for developments associated with wetlands, watercourses and estuaries
Institute of Natural Resources (INR)
No. 2200

Watercourses are able to adapt to changing circumstances, but the current state of watercourses in the country is a clear indication that a threshold is easily reached and impacts of surrounding land uses and human activities can be detrimental. The Reserve, resource class and resource quality objectives are, however, legislative tools developed to reverse or prevent such detrimental impacts/consequences for the resource. The main importance of a buffer zone is to act as a safeguard or a defence against surrounding impacts when resources are stressed or negatively impacted on. The research conducted within this project seeks to identify ways of delineating the riparian buffer zone in order to protect the resource and the riparian fringe in order to provide ongoing protection for the resource. It is envisaged that the results of this buffer zone study, in addition to the appropriate delineation, would be used by all relevant Departments for activities associated with watercourses.

Estimated cost: R600 000
Expected term: 2013 - 2014

Programme 2: River rehabilitation

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KSA 3: WATER USE AND WASTE MANAGEMENT

JAY BHAGWAN | EXECUTIVE MANAGER

KSA 3:
WATER USE AND WASTE MANAGEMENT

SCOPE

This KSA focuses mainly on the domestic, commercial, 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. The 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.

Water use by the sectors differs. The domestic sector generally requires high-quality potable water for drinking and commercial purposes, whereas the industrial and mining sectors require highly reliable and affordable water of adequate quality for their internal processes. Collectively the water usage activities of these sectors generate a large quantity of wastes and wastewater that are detrimental to the receiving environment, and these need to be managed. The supply of the water and the management of the wastes and wastewater are highly synergistic and the technologies and processes are applicable across the sectors.

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

The objectives of the KSA are orientated towards making a difference and impact in the areas of health, economy, environment and society. These are achieved through a portfolio of focused thrusts:

- Thrust 1:Water Services – Institutional and Management Issues
- Thrust 2: Water Supply and Treatment Technology
- Thrust 3: Sustainable Municipal Wastewater and Sanitation
- Thrust 4: Sustainable and Integrated Industrial Water Management
- Thrust 5: Mine Water Treatment and Management.
- Thrust 6: WaterSmart Fund

This KSA continues to build on and strengthen the strategic direction implemented over recent years, as well as with foresight orientating the portfolio to emerging and new issues. Emerging and novel research is channelled into Thrust 6. The scope of the strategic thrusts and programmes within KSA 3 is as follows:

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability are 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	Scope: 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	Scope: 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	Scope: 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	Scope: Regulation of water services is important for the sector to achieve improved functioning and performance in the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.

Programme 5: Water services education and awareness	Scope: A fully-informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of acceptable 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	Scope: 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	Scope: This programme aims to produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.
Programme 3: Drinking water quality	Scope: 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	Scope: The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to 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; and to develop innovative methods, tools and processes that will improve system integrity and reliability.

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: This thrust focuses on the development of technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector. This includes the reticulation, treatment and management of the residues. The challenge is to implement fitting solutions for a particular application that will remain functional throughout the intended lifespan of the installed infrastructure. This includes the responsible management of the wastewater sludge and faecal sludge that is generated. The need for innovative technologies and solutions is recognised as we prepare for the future – achieving more stringent effluent discharge standards, developing acceptable non-waterborne sewerage solutions, reliable treatment of ever-increasing high-strength domestic wastewater, informing future policy, etc.

Programme 1: Emerging treatment technologies – Preparing for the future	Scope: It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as to support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment, etc. It also supports research aimed at informing future policy through data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.

Programme 2: Application of appropriate technologies and tools	Scope: This programme addresses the improvement and innovative application of existing 'fit for purpose' technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate application to consistently achieve strict standards, with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.
Programme 3: Stormwater and sewerage systems	Scope: The programme supports the strategic and technical aspects of managing stormwater and sewerage and their impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology including water-sensitive urban design (WSUD) and stormwater reuse. It will cover technical design, operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.
Programme 4: Wastewater sludge and faecal sludge management	Scope: All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, de-watering, disinfection and beneficiation is encouraged.
Programme 5: Sanitation technology and innovations	Scope: To develop innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Scope: Water is a strategic issue to the industrial sector. While water usage by the industrial sectors is not as great as, e.g., agriculture or domestic consumption, the impacts of the pollutants in industrial wastes and effluents on health and the environment can be significant, costly and long-lasting. The aim of this thrust is to quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycle, recovery and beneficiation. This thrust also aims to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries. In addition, Thrust 4 establishes the governance, policy and regulatory environment that currently exists and the enabling environment that will be required to change behaviours to conserve water, grow the economy, protect society and the environment.

Programme 1: Emerging challenges and solutions for the 21st century	Scope: This programme seeks to look at major challenges that may face South Africa in future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable future industrial complexes and their water management will allow for better planning and regulation of new industries, enabling improved adoption of integrated resource management systems, processes and tools.
Programme 2: Integrated management	Scope: This programme focuses on integrated and innovative management arrangements, e.g., public-private partnerships (PPP), to support industry and government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.
Programme 3: Quantification, prediction and minimisation of water use and waste production	Scope: In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of.

Programme 3: Quantification, prediction and minimisation of water use and waste production (continued)	Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.
Programme 4: Governance, policy, regulatory, and economical instruments to improve industrial water management	Scope: The regulatory authorities are responsible for authorising and regulating the impact of industrial 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 governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective in order to improve, review and enable implementation.
Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents	Scope: This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial activities, and thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycle, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. 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. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse, and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary economy opportunities within South Africa.

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Scope: The usage of water in mining and mineral processing/refining produces high volumes of solid wastes and liquid effluents. Some mining activities generate acid mine drainage (AMD) or other mining-impacted waters. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector. Future operations will almost exclusively take place in water-scarce regions (e.g. Waterberg, Eastern Limb) and their development will require reallocation of already stretched resources through, e.g., improved water demand and water conservation management. Additional priorities will include brine handling, biological sulphur compound transformation and aversion of future impacts.

Programme 1: Water use and waste production	Scope: This programme focuses on investigations into quantification of water used and waste produced by the sector, currently, and predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.
Programme 2: Regulatory, management and institutional arrangements	Scope: The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point-source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: Policy development falls under KSA1).

Programme 3: Minimising waste production	Scope: This programme focuses on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.
Programme 4: Mining in the 21st century	Scope: The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, etc. (especially innovative ideas and piloting/scale-up).
Programme 5: Low-volume mined products	Scope: Much research attention has been paid to coal and gold mining; however, other quarried or mined products such as radio-nuclides and platinum group metals also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.

THRUST 6: WATERSMART FUND

Scope: Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments. Thus, this fund will support research, demonstration and development of any innovative idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed funding budget of R39 526 385. The consolidated research project budget is presented below:

Research portfolio	Approved 2012/13 (R)
Current projects	30 626 385
New projects	8 900 000
Total	39 526 385*

** For the year 2012/13 the KSA over-budgeted by R936 000.00. This is due to an internal transfer of R 500 000.00 due from KSA 2 for a jointly funded project and an amount of R 436 000.00 received as new income from an already committed EU-supported project.*

CORE STRATEGY

Strategic context

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 and continue to grow. Economic growth and development result 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 poses 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.

Although the water requirements for the domestic (rural 4% and urban 23%), industrial (3.5%), power generation (2%) and mining (2.5%) sectors are a fraction compared to total water availability and water consumed, it is the assurance (98%) 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 commercial use of water in the domestic urban areas accounts for 20% of the total urban water use. With the increase in population and the economy, it is projected that by 2025 water demand in the domestic sector will increase to between 30 and 35%. Any future peaks in water demand will affect the assurance levels, resulting in demand being exceeded and vulnerability increasing.

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 service delivery that contribute to 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 low 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 these 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).

A situation of growing dichotomy created by past practices, the current challenges for the water services sector are split into bridging the gap between the poor and unserved in terms of access to water and sanitation services, and supporting the growth of the economy through improving infrastructure and services to industry. The rate of urbanisation is fundamentally affecting the provision of water services and is beginning to result in regular failure of existing infrastructure. The increased migration from rural areas and influx to urban areas is continually putting demands on existing systems. In the rural areas, traditional settlements present significant challenges to service delivery. While many achievements have been made by the water sector over the years in addressing these issues, the greatest and most elusive challenge is the sustainability of these achievements. The lack of investment in infrastructure operation and maintenance over the years, coupled with a skills shortage and lack of investment in replacement of infrastructure, is resulting in many systems failing to meet the requirements of good service delivery. This situation is escalating and is evidenced by the increase in reports highlighting problems.

The situation is further compounded by climate change, shortages of high-quality water sources, growing mega-cities, growing informal settlements, capacity and financial constraints, energy shortages and higher expectations for water, which are challenging the sustainability of the water industry in the long term. 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.

Taking into account all of 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. However, there is a need to develop more 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.

As water consumption continues to rise, Government will face the huge challenge of meeting increasing water supply and wastewater treatment demands. 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.

To achieve the above, 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 must be in place, supported by sound technologies and methodologies. The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas:

In the impact area of **Water and Society**, the KSA contributions are made through understanding the effective demand for water services and the value society attaches to water. It is imperative that in dealing with challenges of water quality and availability, society is fully informed and participates in the management and use of water into the future. Initiatives delve into creating a good understanding of social scarcity and social vulnerability, people's usage of water and establishing a platform for involving society in the local regulation of water services. Some examples of projects which contribute to this impact area are: investigating the social vulnerability of people and their livelihoods and their response to water infrastructure; investigating operational and indigenous knowledge of water use and waste management, and establishing ways to integrate them into water services. In addition, eradicating all forms and types of water and sanitation-related disease, resulting in improvement in quality of life and an increase in productivity, is an ultimate desired impact. Good, clean, safe drinking water and safe sanitation technologies are key ingredients, together with strong institutional support to realise this objective. The KSA achieves this through the development of innovative technologies, improved testing protocols for measuring water quality, identifying emerging pollutants and their consequences on human health, developing sound educational materials and communication techniques and undertaking risk assessments. Some examples of projects which contribute are: the development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply; the development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters; assessment of WatSan and hygiene in relation to home-/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas; development of more user-friendly structures for home-based treatment in rural areas; development of more robust and lighter VIP structures.

The costs and the price of water and water services have a significant impact on the economic growth of the country, since water is considered to be both a social and economic good. Providing affordable water services allows the sector to effectively meet the basic water supply needs of society and stimulate economic growth. Impacts in the area of **Water and Economy** are achieved by undertaking projects which create an understanding of the role of water in economic development at all levels, development of economic instruments for the management of water and stimulating water efficiency. Some examples of projects which contribute are: investigating the mechanisms and processes used in setting water services tariffs; guidelines on pricing and debt management; value of water to the industry.

All activities related to the use of water have a direct and indirect impact on the water environment. The health of our ecosystems and quality of water are key requirements for sustainable water management, and thus the understanding of linkages between the natural environmental components and their interaction with the anthropogenic components within the water cycle are crucial. The KSA contributes to the area of **Water and the Environment**, by influencing the reuse of effluents through developing cutting-edge technologies, establishing monitoring techniques to

enable better regulation, introducing pollutant recovery and minimising processing techniques to minimise the impact on the environment. Some initiatives in this regard are: 'Health for Purpose' in wetlands treating waste streams; beneficiation of agri-industry effluents; development of a zero-effluent mathematical model for wastewater minimisation in a pharmaceutical facility; protocol for quantitative assessment of industrial effluents for discharge permitting; mass balance modelling for wastewater treatment plants; nanotechnology in water treatment; pilot application of a dual-stage membrane bioreactor for industrial effluent treatment.

Linkages to Government Outcomes

The portfolio for 2012/13 was aligned and responsive to Government's Outcomes as highlighted below: Specific activities within each thrust and their contributions are described below:

- The portfolio of programmes and projects in Thrust 1 contribute towards Government outcomes of improving the effectiveness and functioning of local government to provide water services, as well as, importantly, to strengthen regulation and reduce the existing water services backlog while stimulating livelihoods at a local level. With the biggest challenges being in rural municipalities, to date we have investigated institutional options for effective local-level management and delivery of water services. The research outputs on franchising have been realised in an experimental pilot, which is proving to be a successful model and offers one option for municipal arrangements. Supporting this option we have completed a study on people-centred approaches to management of water services. At an urban level, studies have looked at how local people can participate in supporting municipalities, by unlocking procurement and operational hurdles. New initiatives address the concepts of adapted CLTS with the intention of stimulating local ownership, investment and livelihoods in the delivery and maintenance of sanitation facilities, resulting in accelerating sanitation delivery and moving towards Government's outputs on improving access to sanitation for the poor. Ongoing projects are investigating further opportunities or modalities to enhance local levels of service provision and looking at institutional models for both centralisation and decentralisation. Effective municipal institutions are supported by a healthy and robust financial situation, which is one of the key outputs of Government. Three new projects have been initiated which aim to support the strengthening of municipal finances. These look at understanding proper tariff setting, establishing capital investment requirements for regional water management and establishing the funding requirements to completely meet Green Drop requirements. Future research will put greater emphasis on municipal finances and funding of new infrastructure. These initiatives further contribute to and support Government's output towards establishing a robust water economic regulator. In support thereof we have completed studies on the standardising of municipal accounts, since these form an importance base for water services revenue and consumer awareness. New initiatives are looking at how customers value their water services and the resources; this forms an integral part of regulation since user behaviour will influence water use, tariffs and affordability and form the basis for regulation.

- Thrust 2 contributes directly to Outcome 6: 'An efficient, competitive and responsive economic infrastructure network', for example, through the development of an internet-based electronic Water Quality Management System, which provides a tool which will enable the water service authorities and DWA to work together to attain Output 6: 'Develop a set of operational indicators for each segment'. Programme 2 (Water Treatment for Rural Communities) in particular speaks to Outcome 7: 'Vibrant, equitable and sustainable rural communities and food security for all', Output 3: 'Rural services and sustainable livelihoods' and Output 4: 'Rural job creation linked to skills training and promoting economic livelihoods'. The WRC has supported projects to develop appropriate water treatment units based on membrane technology, gravity and wave power, which will not only enable rural households to access clean, safe drinking water but will also foster local economic activity for the servicing and repair of the treatment units themselves. One example is the immersed membrane microfiltration system for the treatment of rural and industrial waters.
- The programmes and projects in Thrust 3 largely contribute directly towards Government outcomes of the protection of environmental assets and natural resources from domestic and industrial waste that is currently treated within treatment plants. This thrust has projects that deal with the development of technologies such as the anaerobic baffle reactor system being piloted in eThekwini Municipality as a decentralised wastewater treatment option for communities. Linked to this is the concept of sustainability, which sees the addition of previously developed WRC-funded flat-sheet membranes and constructed wetlands as technologies for polishing the final effluent to a quality which can be used for small-scale agricultural crops by the community. The WRC has embarked on several constructed-wetlands projects which will feed knowledge, capacity building and know-how into these pilot innovations by municipalities, which can then be replicated elsewhere in the country. The WRC has sought to stimulate new ideas for future wastewater treatment technologies by funding a project on innovative designs (i.e. biomimicry) for constructed wetlands of the future. It has provided solutions for the incremental improvement of nitrogen standards by demonstrating the ability of using South African clinoptilolite as a polishing step at wastewater treatment works. Additionally, projects on sewerage in South Africa, especially for dense informal settlements, will lead to guidelines on technology options and implementation for municipalities. A project looked at management of stormwater using water-sensitive urban drainage principles to lessen pollution loads to rivers and prepare for more frequent rainfall events which may be due to climate change. Indirectly, this thrust touches on providing solutions to Government for supporting rural services, such as 'sewer planning made simple', a set of tools for small rural municipalities, as well as knowledge generation which leads to more effective local government decision-making by repackaging existing knowledge on technology choices and decision support tools in user-friendly poster formats. In partnership with SALGA, WIN-SA, DBSA, DWA and municipalities, this thrust has

also seen the need to capture operational case studies on the infrastructure refurbishment costs, and operation and maintenance and infrastructure asset management efforts, in municipalities.

- The programmes and projects in Thrust 4 were revised in 2010 and largely contribute directly towards Government outcomes of the protection of environmental assets and natural resources from industrial waste. A series of projects relating to membrane bioreactors and membrane technologies have been funded for the pulp and paper, textile, olive oil and chemical industries, which will assist in industries meeting the standards for discharge standards to either the natural environment or municipal sewers. One of the key gaps with the use, and thus the sustainability and cost-effectiveness, of membranes is fouling, and a project under Thrust 3 at the University of the Western Cape has investigated the possibility of designing membranes that foul less. The knowledge derived can be used for both industrial and domestic wastewater treatment. Over 10 years of WRC research on co-digestion of various industrial effluents has led to eThekwini municipality piloting a full-scale implementation at one of its works, for the eventual capture of biogas and the reuse of the final effluent. This builds on a more holistic and sustainable approach to waste management, as set out in Programme 2 of this thrust. The completion of projects such as sustainability factors in industrial complexes has highlighted an emerging concern around brine (salt) disposal and liability. The initiation of projects such as forward osmosis and industrial brine minimisation deals with the emerging issues faced by Government around energy use by different technologies and brine-waste accumulation in South Africa. This thrust also supports local government effectiveness by developing protocols for the evaluation of industrial wastewaters for discharge permitting and technical guidelines for the determination of municipal effluent charges, as a means to encourage industries to switch to cleaner production approaches rather than end-of-pipe approaches.
- The programmes and projects in Thrust 5 were revised in 2010 and contribute directly towards Government outcomes of the protection of environmental assets and natural resources from industrial waste. This thrust also supports local government effectiveness by developing methods for the evaluation of the long-term impacts of mining activities, to encourage industries to switch to cleaner production rather than waste generation followed by treatment. The WRC has been conducting mine-water related research for over ten years. The research is conducted with specific end-user groups in mind. These range from the general public to mine engineering staff, practitioners and specialists. The earlier research projects dating back to the year 1989 were based on gold and uranium mines. The focus areas of these studies were the water requirements and pollution potential of these mines. Subsequent research projects focused on issues such as the impact of mining on the surface water environment, treatment options for mine effluents and the rehabilitation of mine soils. A significant amount of research is conducted on modelling techniques and predictive tools. The studies tackled issues such as industry-

wide water balance, development of low-cost passive water treatment systems and water modelling systems for the mining industry. From the year 2005 the WRC extended its scope to coal mines and acid mine drainage, where it focused on predictive tools for long-term water quality management in underground collieries, as well as the quantification of the potential and magnitude of acid mine drainage under South African open-cast conditions. Support to Government Outcomes is exemplified by the Regional Mine Closure Strategy. In 2005 the Department of Minerals and Energy developed and subsequently implemented a regional mine closure strategy for hydraulically linked mines following a significant array of research conducted by the WRC on mine-water and dating back to the year 1989. Specifically, the WRC published a report on mine closure strategy entitled 'The development of appropriate procedures towards closure of underground gold mines from a water management perspective', which made an important contribution to the DME closure strategy. The premise of the mine closure strategy was that most mines are hydraulically interconnected with adjacent mines. As such the closure of one mine within the region will often have impacts on the remaining mines. The last mine to cease operations in the region also ran the risk of bearing the cumulative burden imposed by all the other mines that ceased operations before it. The mine closure strategy thus assisted in providing an equitable basis to share responsibility between neighbouring mines in the same region. It also contributed to long-term plans to deal with the legacy of poor quality water from mines, thus assisting to address Outputs 1, 3 and 4 within Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'.

- Thrust 5 is directly linked to support Government's output on 'Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water'. As highlighted above, the objective of Thrust 3 is to stimulate innovation and application of novel water-saving and efficiency devices which can, overall, reduce the consumption of water and the generation of wastewater.

Needs analysis

The 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 to strengthen the portfolio of priority research topics and areas requiring attention. We believe that the continuous process of analysing and reviewing our strategy ensures that the KSA remains on a strategic path, as well as responding to challenges of the sector. The new DWA framework, Water for Growth and Development, has set priority imperatives for the water sector and the KSA portfolio is aligned to respond to the challenges posed.

In previous years, interaction with the Minister of Water Affairs highlighted the following areas of priority of relevance to the KSA's activities:

- **Climate change:** need for interventions at provincial and local levels

- **Water conservation and demand management:** more emphasis at a domestic and industrial level
- **Water pollution:** development of technology-based solutions and changing public attitude, as well compliance and enforcement
- **Rainwater harvesting:** Raising its profile, with the need for new technologies and awareness

Similarly, ongoing strategic sessions with a broad representative group of stakeholders, highlighted the following areas of concern:

- Better understanding and management of the water crisis
- Skills development
- Non-compliance issues
- Water security and availability
- Carbon footprint vs. water footprint debate
- Water pollution
- Cost of water to industry
- Improved dissemination and knowledge transfer
- Water quality
- Asset management
- Dealing with acid mine drainage
- Performance of wastewater systems
- Financing of water services infrastructure
- Energy efficiency

In reviewing the wealth of information generated through the various processes, including consultation with DWA and other stakeholders, it was clear that the key challenges facing the water sector in South Africa, as identified in previous years, remained unchanged and warrant greater emphasis and support. The KSA's strategy and focus are in line with supporting Government's long- and short-term objectives, and especially those of ASGISA (Accelerated Shared Growth Initiative for South Africa) and the DWA framework strategy, Water for Growth and Development. These objectives are:

- 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, the introduction of successful models of service delivery which enjoy the support of all stakeholders, addressing 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, eliminating the water and sanitation backlogs.
- 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.

- 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 delivery and hygiene education coverage. These two components are essential ingredients for sustainability and for achieving public health objectives. Focus areas over the short term are to develop appropriate technical solutions, finding cost-effective ways to provide high-impact hygiene education, finding acceptable and affordable service arrangements, models for sanitation delivery and O&M, and improving the legislation and policies that contribute to an enabling environment. 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.
- The energy crisis in the previous years has raised the need for more efficient use of electricity and the need for alternative energy sources. As part of the KSA's objective of efficient and affordable water services, three key variables have been the focus for many years; these being energy, chemicals and materials, which together make up an estimated 70% of the operational cost of providing water services. More emphasis is now being placed on energy issues and proactively we have initiated and promoted many approaches to support this important cause. The research on efficient water use has also been stepped up, and this has a direct bearing on the energy requirements of supplying water services. These areas will continue to grow in an endeavour to meet the needs.
- Gearing the sector towards the impetus created towards water for growth and development.
- 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; the identification and removal of emerging contaminants posing negative health effects; 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 water footprint, 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 made 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, 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 assets need to be managed effectively. Lack of attention over the past few years to 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.
- Industry and mining is facing increasing pressure with the rising cost of water, but also increased scrutiny on the sustainable use of the resource. The concept of a 'water footprint' is an emerging and effective tool being developed to assist industry to scrutinise their activities and continuously strive to reduce their footprint on the environment.

Overview of technological trends

At an international level key pressures which drive research and solutions are:

- Economic development and population growth
- Increasing demand for food, energy and water
- Global and regional changes to the climate
- Degradation of water quality
- Risks associated with infrastructure deterioration

Thus there is a continuous move towards new approaches to the provision of water services and adaptation of new approaches to improve domestic water quality and availability of water through alternative advanced technologies. Within these objectives climate change and energy efficiency are now becoming key drivers and influences. In the quest to achieve efficient and sustainable water service delivery, it is becoming more and more important to include these two variables or factors, which have a significant impact on the continuous provision of services. Against the background of South Africa's current electricity challenges, energy efficiency and wise water use are priorities.

A trend in developing countries is to decentralise or devolve the management of services to a local level or to a local government level, with the national authorities moving into a stronger regulatory role. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries where 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.

Internationally, 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 for these emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues to be on breaking the transmission cycle of faecal-oral and water-related diseases through understanding the practices and

behaviours which contribute to their spread. Improved education and knowledge are central strategies to tackle these problems.

In the quest for improving the water quality delivered to consumers, there are growing needs for improved analytical methods to analyse for undesirable and emerging contaminants. In this regard new improved methods are continuously being investigated, keeping up with the international trends.

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 being seriously 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 to 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, 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. Increased activity in the field of mine-water has resulted in the creation of a dedicated thrust with two entirely new programmes to cater for it. 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 Minister of Water and Environmental Affairs is the shareholder of the WRC, and DWA and DST are its key

stakeholders. In addition, the following stakeholders also continue to be of key importance to the WRC in general and to this KSA in particular. They comprise both 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, with the shareholder being the Minister of Water and Environmental Affairs.

The external stakeholders include:

- Government ministries and departments (Water and Environmental Affairs, Cooperative Governance and Traditional Authorities, Health, Mineral Resources, Science and Technology, Education, Human Settlements, etc.)
- Beneficiaries (i.e., the users or potential users of research, development and knowledge products produced through WRC funding)
- SALGA, local government, provincial government units; including one-to-one interactions at the local and district municipality level
- 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 (Water Institute of Southern Africa (WISA), South African Institute of Civil Engineering (SAICE), Institute of Municipal Engineering of Southern Africa (IMESA), etc.), media agencies
- The public
- International coalitions such as Global Water Research Coalition (GWRC), Water Supply and Sanitation Collaborative Council (WSSCC), Water Utility Partnership (WUP), Emerging Technologies (ET), United Nations Environment Programme (UNEP), International Resource Centre (IRC), Water Research Fund of Southern Africa (WARFSA)
- The business sector

Providers

Providers are solicited or unsolicited individuals and organisations who generate research, development and knowledge products with WRC funding. The key providers are tertiary institutions, science councils, consultants, NGOs, water boards, research units within government departments and local government, private companies and individuals.

RESEARCH PORTFOLIO FOR 2012/13

The results of the strategic needs analysis and its review, needs expressed by the Minister of Water and Environmental Affairs through the variety of workshops and seminars, and engagement with DWA and other stakeholders with regard to its objectives and thrusts, have been well supported. Reviews highlight that the

relative weight of this KSA's thrusts seems to be well-balanced regarding the needs of urban-industrial-mining and rural research needs. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio.

During 2012/13 the portfolio continued to build on the strategic changes from previous years, as well as strengthen the portfolio towards making greater impacts on the social and health aspects, environment and economy of the country. In summary, we do not foresee any major changes to the KSA strategy and portfolio of thrusts over the next few years.

The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the new DWA framework strategy, Water for Growth and Development (Version 6). The strategic context of the KSA and its activities respond to the WRC five-year strategy. Within this context the KSA will put greater emphasis over the next few years on the following concepts:

- One Water – this is based on a vision that there is no wastewater in the system and that all qualities of water are a resource for use.
- Resource recovery – this promotes the view that there are and will be no pollutants in the sources of water, only resources which can be recovered for beneficiation offering opportunities for direct reuse.
- Energy resource – the role of water resources in the efficient use of energy, as well a net contributor of green energy.

The new portfolio of projects for 2012/13 continues to provide 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
- Management of brines
- Management of acid mine drainage
- Extending the implementation of water footprints, waste minimisation, cleaner production, cleaner consumption and clean technologies
- Climate change adaptation and mitigation
- 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

- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology
- Investing in emerging contaminants affecting water quality, especially trace organics
- Energy efficiency and generation, as well as the energy water nexus
- Institutional strengthening – financing, regulation, etc.

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Assessing the impact of expansion of bulk infrastructure on capital requirements of Water Boards
Palmer Development Group
No. 2086

Water Boards were established under the Water Services Act of 1997 to provide bulk water to other water services institutions and to serve as water services providers when contracted by municipalities. A number of recent initiatives have been aimed at expanding the operations of Water Boards. Expanding the areas of activity of Water Boards will have an impact on their financial viability, most notably on capital expenditure requirements. As a result, the WRC supported this study to conduct research on the impact of expansion of bulk infrastructure on the capital requirements of Water Boards. The study involved two main streams of work. The first stream focussed on modelling the impact of expanding areas of activity on the financial viability of Water Boards; the second on identifying indicators for assessing the ability of Water Boards to access capital finance, particularly under expansion. The results from this study highlight the fact that the expansions to Water Boards' footprints and activities proposed under the IRR process pose considerable challenges. Expansion will require the Water Boards taking on significant new assets and incurring considerable capital expenditure over the next 20 years. This will place strain on operating accounts, and on the ability to raise capital. When considering the implications of expansion, an assessment of the performance and structure of the municipal areas into which the Water Boards are being asked to expand is vital.

Cost: R767 845
Term: 2011 - 2012

Programme 2: Institutional and management issues - Water services

Guidelines on condition assessment of water services infrastructure
University of Pretoria
No. 1950

The management of physical assets involves a wide scope and range of processes including acquisition, control, use and disposal of the assets in a manner that satisfies the constraints imposed by business performance, environment, ergonomics, and sustainability requirements. The focus of this research is on condition assessment of the water services infrastructure components and the development of guidelines for the condition assessment of these components. The objective was to focus on what should be done and therefore the research did not address

any detail of a prescribed protocol of how condition assessment for the different system components should be conducted. The methodology included the review of existing operational information to gain insight into the procedures followed to conduct asset management and to relate the operational experience to the remaining useful life by formulating a relationship between the status and remaining life. The outputs emanating from the study include:

- Data requirements to define the water infrastructure components
- Conceptual model between performance and life expectancy
- Applicable non-destructive techniques for condition assessment of water transfer
- infrastructure
- Description of the economic evaluation techniques to compare replacement or refurbishment
- Development of software (spread sheet) to determine the remaining useful economic life

Cost: R338 657
Term: 2009 - 2012

Development of protocols and guidelines for municipalities to undertake studies to determine the impact or influence of climate change on water service delivery
University of the Witwatersrand; Gondwana Environmental Solutions (Pty) Ltd; University of Pretoria; Rand Water; CSIR
No. 1953

Water services management is likely to be one of the most complex problems facing South African municipalities in the future. There is a strong link between water services and climate variability around the country. Trends towards greater urbanisation and densification, coupled with environmental changes such as climate change, are likely to exert pressure on water resources. It is necessary for strategic planning at a local government level to avoid water supply challenges in the future. The risk that climate change poses to water supply and demand is growing both globally and locally. Incorporating climate change projections and their implications into municipal management is gaining support in cities around the world (e.g. London, New York). Projected climate change is important for various planning horizons, particularly those that aim to address climate and development issues in the short and longer term. Improving the understanding of current storm risks is not purely for the benefit of the science-policy dialogue, but for that of affected communities. Efforts also need to be made to understand how flood risk is framed and perceived by those most affected by such storms. The purpose of this study was to evaluate the impact that climate change is likely to have on water services management for a local authority in South Africa by modelling future climate scenarios for South and Southern Africa, identifying the risks associated with the expected consequences of the predicted changes in climate and evaluating the impact on water management using a hydrological model. The key findings emanating from this study indicate that municipalities will have to deal with more frequent high-intensity short-duration storms. This is going to put huge pressure on existing drainage infrastructure such as stormwater and sewerage systems, but will also have an impact on associated infrastructure such as road, buildings etc. Low-lying low-income settlements were identified to be the most vulnerable and proper planning and intervention is required now to avert any future crisis.

Cost: R700 000
Term: 2009 - 2012

Programme 3: Innovative management arrangements - Rural water supply

Franchising partnerships for operation and maintenance of water services
CSIR
No. 1952

Year after year, the operation and maintenance of too much of South Africa's water services infrastructure has been found to not comply with the required standards. Breakdown of service delivery is too often the outcome. The primary objectives of the Butterworth schools sanitation and water servicing pilot project was the demonstration of the suitability of social franchising partnerships under these circumstances, and the development of a model which can be used for rolling out similar services to the rest of the more than 4 000 rural schools across the Eastern Cape. These objectives were successfully achieved. The pilot was extended to the pit-emptying of 400 household toilets for the Amathole District Municipality. This was also completed successfully. In short, the franchising partnerships concept, as it has been applied in the Eastern Cape pilot, has been an unqualified success in terms of the quality and reliability of service delivered.

Cost: R4 800 000
Term: 2009 - 2012

Bridging the policy divide: Women in rural villages and the Water for Growth and Development Framework
Mvula Trust
No. 1988

The study investigated the implementation of water legislation and policies at the grassroots level, evaluating whether the intentions of specifically the Water for Growth and Development framework to bring water services and water resources together in support of women as strategic users of water, and in particular rural women's use of water for their emerging productive activities, were being met in reality. The study also examined the extent to which local authorities meet their developmental mandate to promote local economic development by supporting rural women's multiple uses of water. Women in rural areas use water for domestic use but also for emergent productive use to sustain their livelihoods and develop incomes for themselves and their households. This means women are local economic actors as envisaged in the Water for Growth and Development policy. Water policy, in particular water resource management policy such as the National Water Resource Strategy and Water Allocation Reform Strategy; recognises that equity in access and use of water should be secured for emergent productive users of water, such as women in Strydkraal and Apel. The lack of formation of water resource management structures has seriously impeded women's development as emergent users of water for productive purposes. While both policy and legislation recognise the need for equity in post-1994 water management and supply, policy goes further to identify emergent productive water users such as women as a sectoral group that requires servicing and assistance for its water needs. The National Water Act gives these policies legal force through water resource management structures and processes- such as WUAs, CMAs, Catchment Management Strategies and Allocation Plans, which were envisaged to be in the forefront of supporting emergent productive water users to sustainably pursue their livelihoods and economic activities.

Cost: R596 000
Term: 2010 - 2012

Strategy for large scale roll-out of community-based service provision
Palmer Development Group; Mvula Trust; North-West University (Potchefstroom); University of Pretoria
No. 2090

The central tenet of this research study was to identify the key factors of success for the large-scale implementation of community-based service provision; and to draft a strategy on integration of community-based water services provision. The study has developed a Strategy for the Upscaling of Community Based Service Provision. The vision of the Strategy is for every household and enterprise requiring potable water in rural areas to have access to a safe and reliable water supply, for poor households to have access to a basic water supply free of charge, for those that are not poor or who consume water in amounts above the free basic water limit to pay for water, and for water to be conserved with an emphasis on avoiding losses in distribution systems. The Strategy provides a definition of what a Community-Based Partner is and outlines a range of options and arrangements for involving the community in water supply. The research presents an approach by which local and national government can respond to water service provision in largely rural areas using community-based operators. The findings from this research can also be used to target the support strategy for the 21 presidential districts.

Cost: R645 500
Term: 2011 - 2012

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Development of a durable and reliable Wave-Energy Reverse Osmosis Pump (WEROP) desalination system
The Impact-Free Water Group; University of the Western Cape; Confluence Associates; African Centre for Water Research; AH Associates; Environmental Monitoring Group; Institute for Maritime Technology; University of Stellenbosch; UNISA; University of Cape Town
No. 1716

In recent decades South Africa has witnessed a rapid shift from scattered inland populations to concentrated coastal development. In 20 years some estimate that more than half the population will live within 10 km of the shore. This zone is already the most water-stressed and ecologically fragile strip in the country, pushing groundwater pumping and surface storage to costly and dangerous limits. This project developed a prototype of an alternative water supply technology that works with nature rather than against it. We call it a Wave Energy Reverse Osmosis Pump, or WEROP. Primary research was carried out on site around the Cape Peninsula, using constructive feedback and lessons learned to improve operation and design of the WEROP. Despite difficult working conditions, the model unit proved to be relatively straightforward to assemble, deploy, and operate. Over several months it remained very durable, with little corrosion despite the lack of paint, with little maintenance required other than replacing the sacrificial anodes. The unit has been tested to 90 bars, which is far higher than the 62 bars required for reverse osmosis. It was shown that, in theory, this could be pushed to an average of 2 500 L/day in an average sea with a

wave height of 0.5 m and a period of 8 s. This is rather conservative, as the average period of wind chop is around 4 s, thus doubling production. A wave height of 0.5 m is also very modest, as the waves found in the target area are on average over 1 m in height.

Cost: R1 400 450
Term: 2007 - 2013

Assessment of the prevalence of organic compounds in raw and treated water for potable purposes, their fate in current treatment plants, and compilation of a guideline on best available technology for the removal thereof
University of Johannesburg; Chris Swartz Water Utilisation Engineers; Technical University of Delft
No. 1883

This project investigated the nature of natural organic matter (NOM) appearing in source water in the relevant parts of the country, and presents an assessment of the efficiency of selected drinking water treatment plants. The plants reflect typical unit processes used throughout the country. The report classifies the NOM categories according to their removal efficiency. Work on actual plants was supplemented by suitable bench-scale process simulation investigations, since the treatment performance of full-scale treatment plants did not provide sufficient detail, and extensive bench-scale work was required to provide a large enough database. Three advanced methods were sufficiently developed to apply in the project, namely BDOC, FEEM and modified PRAM. Suitable existing and novel techniques and processes which could be employed to remove the problematic NOM fractions were identified, and included enhanced coagulation, activated carbon and nanoporous polymers. Enhanced coagulation and carbon adsorption were thoroughly covered. Ion exchange (both weak and strong resin) was covered in less detail. Ozonation was addressed through a limited number of samples from full-scale treatment plants. Some exploratory work on nanomaterials was included towards the end of the project. A guideline on the efficient removal of NOM from South African source waters was compiled and is included in the final report.

Cost: R1 800 000
Term: 2009 - 2012

Development of a costing model to determine the cost-efficiency and energy-efficiency of water treatment technologies and supply options
Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology; Development Bank of Southern Africa; GO Water Management; Umgeni Water
No. 1992

This project developed a user-friendly costing model, WATCOST, for estimating costs of drinking water supply systems. This allows economic comparison between different water treatment and supply options being considered for a water supply scheme. It also allows costing reports to be done for existing water treatment systems, which assists with budgeting and asset management processes. The aim of WATCOST is two-fold: firstly, the manual can be used as a reference document for information on costing data for water supply projects, with actual costing figures that can be obtained from the tables and graphs in the document. Secondly, the manual is also an aid when using the WATCOST model to obtain costing data for water supply projects, either in total or for specific components in the drinking water supply cycle. The WATCOST Costing Model is available electronically, downloadable from the WRC website. The model will also be available on

a CD inside the manual. The electronic copy of the model on CD contains the following: user instructions, input component (where the user will enter required information), software that will do the cost calculations – the model component, output component (that will provide the tables and graphic costing results), and a database of costing information (not accessible to the user, only for doing cost calculations). The WATCOST model is aligned with the DWA costing model, so that it can be integrated with this model as required.

Cost: R776 800
Term: 2010 - 2012

An independent investigation into the purification capacity of small-scale water purification units manufactured and supplied in South Africa
National Institute of Occupational Health; University of Pretoria; University of Johannesburg
No. 1994

Recent failures in potable water delivery as well as outbreaks of waterborne diseases in South Africa have led to members of the public investigating the use of home water treatment devices (HWTDs) to ensure that their tap water is safe for human consumption. Very few independent studies have been published on the capacity of HWTDs to effectively treat water. The majority of publications refer to projects which only tested for a single organism or compound and/or a single product. To date, only two studies have been published where HWTDs were tested for more than one compound. A need therefore existed for an independent study to evaluate a representative number of units sold in South Africa against the claims that are made in sales brochures. The study evaluated the performance capacity of tap mounted and jug-type HWTDs available in South Africa for domestic use, with regard to their ability to remove microorganisms under a variety of running conditions as prescribed by the National Standards Foundation, and to compare the findings to the SANS241 requirements for potable water quality and with the claims made by the manufacturers of the products. Most of the HWTDs tested within this study could potentially improve the water quality in terms of its aesthetic attributes (such as reducing scale), but in terms of taste, odour, heavy metal and microbiological reduction claims, the HWTDs tested performed poorly compared to the manufacturers' claims. Devices which used ultrafiltration and sediment filtration mechanisms were most successful at reducing bacteria and cysts, however none of the HWTDs tested removed viruses. Most of the devices tested decreased or removed chlorine. In terms of turbidity, mechanical reduction and dissolved solids assays, ultrafiltration and sediment water treatment technologies were the most successful at excluding particles in water. None of the HWTDs tested reported any success of reducing fluoride in water. Some of the HWTDs removed copper, aluminium or zinc from water but none was effective at removing iron, manganese and lead. Most of the HWTDs failed to remove carbon; conversely, some of them added to the total organic carbon in the water. This is a concern as carbon is a substrate for microbes which could lead to fouling of HWTDs. Lastly, most of the HWTD's failed to comply with NSF P231, 42 or 53 and SANS 241:2006 water treatment device standards and most of them did not meet the claims made by their manufacturers.

Cost: R809 000
Term: 2010 - 2013

Energy efficiency in the South African water industry: a compendium of best practices and case studies

Chris Swartz Water Utilisation Engineers; The Water Group; Waterscience cc; Amatola Water

No. 2092

Energy will in future become a high-cost item for municipalities and utilities which operate and maintain water and wastewater processes. Energy consumption will continue to increase as more people are provided with water and sanitation and new technologies are implemented to meet stricter effluent and potable water quality requirements. To position the water sector globally with regard to energy consumption, the Global Water Research Coalition (GWRC) embarked on a project entitled Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies, which looks at these best practices worldwide. The project is supported by the GWRC partners world-wide as represented by the four Continental Coordinators in Australasia (Australia and Singapore), Europe, South Africa and the USA. Each continental group created a report of best examples submitted by utilities in their region. The four continental reports, when available, will be compiled into the global compendium. The report by the UK Water Industry Research Ltd. (UKWIR, 2010) on energy efficiency in the UK water and wastewater sector concluded that overall energy efficiency gains of between 5 and 15% may be achieved, with up to 25% energy efficiency improvement in wastewater treatment processes (mainly activated sludge processes).The report further indicated that renewable energy, mainly in the form of combined heat and power (CHP) from sludge gas, could contribute significantly to the net energy demand of the water industry. A similar report was compiled by the Water Environment Research Foundation (WERF, 2010) in the USA, and provides best practices for the energy-efficient operation of wastewater industry assets in North America. The WRC, as partner of the GWRC, has funded the current project to develop a Compendium for the South African water industry. The scope of work covered the principal activities of water and wastewater businesses and focused on the identification of current best practice, tools and technologies. The study evaluated both incremental improvements in energy efficiency through optimisation of existing assets and operations, and substantial improvements in energy efficiency from the adoption of new technologies. It also highlighted new processes, plant types and systems which realise more substantial energy gains. Water and wastewater treatment plant surveys were conducted to document case studies and examples of best practice.

Cost: R1 000 000
Term: 2011 - 2013

Programme 3: Drinking water quality

β-*N*-methylamino-L-alanine bioaccumulation and bio-magnification: Health risks and water treatment possibilities

Nelson Mandela Metropolitan University; Cripsis Environment; IGB- Leibnitz Institute of Freshwater Ecology and Inland Fisheries

No. 1885

β-*N*-methylamino-L-alanine (BMAA) is a neurotoxic amino acid produced by cyanobacteria. BMAA is implicated in neurodegenerative disease as it causes motor neuron damage at fairly low concentrations. Potentially harmful BMAA within cyanobacterial cells may be released on cell senescence. Collapse of a substantial cyanobacterial bloom may result in release of large amounts of the toxin into water. The aims of this project were to evaluate potential risk to consumers, the fate of the toxin in the environment, the environmental

consequences of BMAA in the water, and the potential for contamination of drinking water. Data suggested that BMAA is rapidly taken up by a wide range of organisms and becomes freely available in food webs. Furthermore, data showed that bioaccumulation occurs in certain species while biotransformation can occur in some species. Standard methods including sand filtration, chlorination and the use of activated carbon were all successful at removing BMAA at laboratory scale. The absence of BMAA in any treated water tested, including treated water from bloom-containing raw water, confirms that standard water treatment practices adequately protect consumers from BMAA at known concentrations in raw water.

Cost: R1 800 000
Term: 2009 - 2013

Nanotechnology solutions for drinking water
Rhodes University
No. 1991

The work focused on nanotechnology-based solutions for drinking water in which electrospun nanofibres were used for removal/detection of contaminants in water. The aim was to develop electrospun nanofibre-based devices for water purification as well as monitoring of water quality. Nanofibres were fabricated by electrospinning. The experimental approach consisted of evaluating the recognition principle (compounds or metallic nanoparticles) responsible for selectivity in solution phase, then incorporating it in or on a nanofibre platform. The objectives of the project were to: (1) develop sorbents for uptake of metals in water; (2) develop nanofibres with antimicrobial properties for control of pathogens in water; (3) develop optical probes for the detection of heavy metals and organic contaminants in water; and (4) develop enzyme/substrate immobilised electrospun nanofibres for removal and monitoring of contaminants in water. All four objectives were achieved. Sorbents were developed for uptake of metals, and were demonstrated to be selective for arsenate species. The uptake of arsenate was not affected by competing anions. The interaction between arsenate and the electrospun nanofibres is suspected to be via hydrogen bonding of the anion with the hydroxyl groups on the primidine ring. Nanofibres incorporated with 2-substituted N-alkylimidazoles showed excellent antimicrobial activity against Gram-positive bacteria. Electrospun nanofibres incorporated with silver(I) complexes showed a broader spectrum antimicrobial activity, attributed wholly or partially to the silver(I) ions, depending on the type of microorganism. Optical detection probes were developed which discoloured in the presence of Ni(II) but not when exposed to other metals. Another probe, for the colorimetric detection of 17β-estradiol, was developed using gold nanoparticles in electrospun nylon 6 and polystyrene polymer nanofibres. This probe was also highly selective for and sensitive to the target compound. The research detailed in this report has enhanced the understanding of the use of electrospun nanofibres as a platform for water purification and contaminant detection strategies. The new probes invented during this project are protected by patents 2012/08972, 2012/08973 and 2012/08971.

Cost: R1 800 000
Term: 2010 - 2013

Scoping study and research strategy development on currently known and emerging contaminants influencing drinking water quality
University of the Free State;
University of Pretoria; Dames
No. 2093

The aims of this project were to review literature on emerging contaminants (ECs) in drinking water and identify three critical ECs for which (a) analytical methods would be reviewed, (b) a national reconnaissance survey performed, and (c) a risk matrix developed. Critical EC-related issues would be also identified and a future research strategy developed. Three contaminants were chosen for the national survey: atrazine (herbicide), carbamazepine (analgesic and anticonvulsant) and terbuthylazine (herbicide). Samples were taken of treated drinking water in Bloemfontein, Cape Town, Durban, Johannesburg, Pietermaritzburg, Port Elizabeth, and Pretoria. Samples were taken in February, May, August and November of 2012. All samples were quantitatively analysed using HPLC-MS for the three selected contaminants. All samples were also qualitatively screened for the presence of over 600 possible contaminants using liquid chromatography tandem mass spectrometry (LC-MS-MS). The LC-MS-MS screening analysis revealed the presence of a total of 38 pesticides or pharmaceuticals. The HPLC-MS analysis showed that even the maximum concentrations of atrazine, carbamazepine and terbuthylazine were more than 10 times less than maximum contaminant levels set by the US EPA. A national programme should be considered in which drinking water is seasonally or bi-annually qualitatively screened, and frequently-observed ECs are quantitatively analysed. It is also recommended that a similar qualitative screen and quantitation of the level of selected ECs be undertaken in one or more rural communities that routinely use raw water directly from rivers and dams. A study is also recommended on the presence of pharmaceuticals in borehole water due to leaching from medical waste dumping grounds.

Cost: 598 900
Term: 2011 - 2014

Verification and validation of analytical methods for testing the levels of PPHCP (pharmaceutical and personal health care products) in treated drinking water and sewage
UNISA
No. 2094

The main aim of this work was to develop, verify and validate appropriate analytical methods for hormones and other pharmaceuticals and personal health care products (PPHCPs). The focus was on using charged aerosol detector–high pressure liquid chromatography (CAD-HPLC). PPHCPs and their metabolites have been recognised as a group of the emerging contaminants in aquatic environments. Effluent from wastewater treatment works (WWTWs) is one of the major routes by which these compounds enter the environment. The large number of potential compounds and their diversity creates specific analytical challenges. A separation method was developed for the 12 non-hormonal PPHCPs which showed good linearity and accuracy. Relatively high limits of detection and quantification were obtained making them likely to be applicable to the higher concentrations one might expect in wastewater treatment plants but not in drinking water. Some PPHCPs were detected in WWTWs influents and fewer in effluents.

Cost: 500 000
Term: 2011 - 2013

Programme 4: Water distribution and distribution systems

Determining the change in hydraulic capacity of pipelines
University of Pretoria; Cripsis Environment; Rand Water; TCTA
Rand Water
No. 1820

It is generally accepted that the operational life of pipelines could well be longer than the 30 years which are used in the economic analyses of pipeline systems. Networks of Rand Water and other water utilities prove this, although there are a number of reported cases in which pipelines failed short of the expected operational lifespan. Funding of new water projects in the near future will have to compete with the capital that is required for the renovation, replacement and upgrade of existing infrastructure. An informed status assessment of a pipeline can only be made if the operational performance history of the pipeline is known. Optimal capital expenditure and operational cost is based on the performance and expected hydraulic performance decay rate of pipeline systems. Long-term performance data is essential for this assessment and an effort should now be made to gather information on a regular basis for a number of different pipelines in South Africa. This project highlighted the general lack of hydraulic performance history; hence little information is available to be considered for the hydraulic assessment and future planning of extensions or improvements to system components. Monitoring the performance of infrastructure provides knowledge to make informed decisions on the limitations and decay of the system and to optimally determine the required upgrade and extensions to the system. The expected high-energy cost in South Africa highlighted the importance of re-assessing the energy efficiency of pumping systems. In this regard a decision diagram has been developed to guide the decision whether to upgrade, replace or rebuild sections of the pipeline system. The influence of biofilms on hydraulic capacity and the energy losses occurring at field joints of pipelines needs to be researched in further detail.

Cost: R785 000
Term: 2008 - 2011

Full-scale trial to investigate the correlation between modelled and measured residential water demand and wastewater flow based on end-use modelling
University of Stellenbosch; Overstrand Municipality; AVDM Consulting Engineers
No. 1995

The objective of this study was to correlate measured and modelled water use at a high spatial resolution and time scale, in order to assess diurnal patterns and peak flows for individual properties. An 'end-use' of water has numerous definitions and meanings in the literature depending on the scale of the investigation. An end-use may be either an indoor end-use or an outdoor end-use. Typical outdoor end-uses include garden watering and a swimming pool, while indoor end-uses include toilet, bath, shower, (clothes) washing machine, dishwasher, etc. The focus of this work was on indoor end-use. The water use in both study areas was compared to the theoretical peak flows and derived peak factors, based on the end-use model. The theoretical 15-minute peak factor was found to be 62 for a single house, that is in the range of the recorded peaks. However, it was unexpected to find such a large variation in actual peak factors from one home to the next.

Cost: R842 000
Term: 2010 - 2013

Compendium of case studies relating to water loss and water demand interventions at the municipal level in South Africa
Resolve Consulting
No. 1997

The need for demand-side interventions that effectively reduce physical losses in water networks, artificial demand at the end-user level created through leakage, as well as apparent losses due to metering and billing deficiencies, is abundantly clear. In response to this need, municipalities across the country have initiated interventions, programmes and projects to reduce the demand for water, with varying levels of success. Aimed at identifying, documenting and disseminating the experiences of municipalities in water demand management, the WRC directed the development of a compendium of case studies relating to water demand management at the municipal level in South Africa, presenting 40 case studies in an anecdotal easy-to-read format. The presented case studies highlight not only best practice in the industry, but also less effective approaches that can potentially achieve greater effectiveness through improved management and implementation. It is hoped that technical, financial and managerial officials of municipalities, as well as councillors, community leaders and communities themselves, will use this compendium as a tool to identify, conceptualize, formulate and implement initiatives based on the case studies presented that effectively address water demand and reduce water wastage.

Cost: R545 195
Term: 2010 - 2012

Apparent losses in selected areas in South Africa
University of Cape Town
No. 1998

While apparent losses look like real losses to a municipality, this is not actually the case. The main components of apparent losses are water meter under-registration and unauthorized consumption, but meter reading and data errors are also contributing factors. Thus the objective of this study was to estimate the extent of apparent losses due to meter under-registration in South Africa. The occurrence and flow rate distributions of on-site leakage were measured in Cape Town and Mangaung using the same methodology as an earlier Johannesburg study. The study found that, based on on-site leakage investigations in Cape Town, Mangaung and Johannesburg, it is estimated that the meter under-registration error for on-site leakage will be 15% of the registered leakage rate. This is equal to roughly 2.2% of demand. The total meter under-registration error in middle- to high-income areas is thus estimated to be 5% of consumption. In low-income areas, on-site leakage occurs with much higher incidence and thus meter under-registration can be expected to be higher. A review of meter audits done on bulk consumers showed that a lot more needs to be done to ensure that these meters are correctly sized and installed and in good condition. Based on the increase in revenue investigations after the meter audits performed in Tshwane and Ekurhuleni, it seems that the apparent losses of bulk consumers are potentially around 20%.

Cost: 400 000
Term: 2010 - 2012

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies– Preparing for the future

The development and commercial exploitation of a suite of technologies to supplement the Biosure process
ERWAT; Phatamanzi Minerals (Pty) Ltd; CSIR (NRE); Keyplan
No. 1780

The development of the BioSURE Process commenced at Rhodes University in the early 1990s. Following bench-scale studies, the process was scaled-up to a pilot plant (Corbett, 2001) with a treatment capacity of 40 m^3/day located on-site at Grootvlei Mine in Springs, Gauteng Province. This plant operated for 18 months treating an AMD stream with a sulphate load of approximately 2 000 mg/L. Kinetics and engineering studies were then conducted at the Water Research Group, Department of Civil Engineering, University of Cape Town (Ristow, 1999, Ristow et al. 2002; 2005), resulting in the design and successful operation of another pilot-scale operation at the ERWAT Ancor WCP, Springs, with a treatment capacity of up to 2 ML/day. A 2.4 km pipeline has been constructed to feed mine water from Grootvlei Shaft No 3 to the Ancor WWTP. This investigation showed that using the correct reactor configuration, with strict control over the mine water flow rate and the primary sludge dosing rate, the biological process could reliably remove sulphate to concentrations below 100 mg/L at hydraulic retention times as low as 12 h. Based on these positive results, and with a degree of safety in the design, a full-scale plant was designed to treat 10 ML/d of mine water from Grootvlei Shaft No 3 in Gauteng, South Africa (Neba et al. 2006; Neba, 2007). The successful construction, commissioning and operation of the full-scale 10 ML/day BioSURE Process provided useful information on the following aspects:

- Demonstrated that the plant can operate well and meet strict effluent standards
- Confirmed the accuracy of the kinetic model and process design criteria, but also gave a clear idea of the operating limits of the plant
- Highlighted the importance of meeting the minimum COD/SO_4 requirements
- Emphasized the need to improve the process to remove hydrogen sulphide from the effluent
- Further pilot studies indicated that the biological sulphate-reducing process (BSRP) is able to convert permanent hardness into temporary hardness that allows the use of cold-lime softening processes to desalinate the water
- Offered the opportunity to consider the option to utilize waste organic material other than PSS (primary sewage sludge), such as abattoir and dairy waste as carbon and energy source; this scenario allows the possibility to reduce the load on the existing landfill-sites and limit the leachate production potential and offers an opportunity for revenue generation.

Cost: R1 350 000
Term: 2007 - 2012

The optimisation of waste stabilisation ponds by combining duckweed-based and algal-based systems, together with aerated rock filters
Africa Remediation Technology; Tshwane University of Technology
No. 2005

Wastewater stabilization pond (WSP) technology is one of the most important natural methods for wastewater treatment, especially in rural areas. It was found that while there was a wealth of information available on the design considerations for algal pond systems, there was a lack of information on duckweed-based systems, particularly with respect to the optimal growth conditions, expected nutrient uptake rates and recommended harvesting rates for removal of nutrients from the system. This study therefore focused on duckweed-based treatment at a pilot scale. The following conclusions and observations were made from the studies undertaken:

- The surface density of duckweed in the duckweed ponds is important. If too high, the plants will have limited access to nutrients in the upper layers, and limited light, gas exchange and space to grow, reducing the potential for nutrient uptake.
- The harvesting rate is important for the maintenance of the correct surface density and to allow for the growth of the duckweed to reach its full potential. If the frequency of harvesting is too high, young plants will continually be removed from the system.
- At the concentrations of nutrients tested under the artificial light conditions with low light intensity, higher concentrations resulted in lower growth rates and wash out of the cultures at the harvesting rates tested, especially at the lower temperatures of 13 and 18°C. Thus at lower temperatures for full-scale duckweed systems it may be necessary to dilute the influent with either final effluent of the treatment system or of the duckweed ponds themselves through a recycle.
- At lower nutrient concentrations, where duckweed were expected to be nutrient limited, it was observed under all temperatures and light intensities that the roots and fronds of the *Lemna* spp. increased in length and size.
- Duckweed preferentially take up ammonia nitrogen as a nitrogen source, rather than nitrate. Duckweed ponds must therefore precede algal ponds, rather than vice versa, as ammonia nitrogen will be converted to nitrate nitrogen through nitrification in the aerobic environment of algal ponds. It is also important that an anaerobic process precede the duckweed stage, where organic material can be mineralized and ammonia-nitrogen and ortho-phosphorus released in the bulk liquid.
- The light intensity and temperature applied to a mixed duckweed culture affected the species composition, with *Lemna turionifera* being the dominant species under high light intensity in the sun, and *Wolffia* spp. dominating under medium light intensity in the shade.
- It is important that the duckweed layer not become mass transfer limited, as this will result in low nutrient uptake. Introduction of turbulence in the duckweed treatment system is therefore a requirement, either by gentle mechanical mixing or through the use of baffles.

The results of the laboratory study were applied to develop potential conceptual designs for a pilot-scale trial proposing several configurations for an integrated WSP system.

Cost: 1 000 000
Term: 2010 - 2012

Programme 3: Stormwater and sewerage systems

Alternative technology for stormwater management
University of Cape Town; City of Cape Town; eThekwini Municipality; IDS (Information Decision Systems); Johannesburg Municipality; SRK Consulting (SA) (Pty) Ltd; Tshwane Metropolitan Municipality
No. 1826

Stormwater management in the urban areas of South Africa has been, and continues to be, predominantly focused on collecting runoff and channelling it to the nearest watercourse. This means that stormwater drainage currently prioritises quantity (flow) management with little or no emphasis on the preservation of the environment. The result has been a significant impact on the environment through the resulting erosion, siltation and pollution. An alternative approach is to consider stormwater as part of the urban water cycle, a strategy which is being increasingly known as Water Sensitive Urban Design (WSUD) with the stormwater management component being known as Sustainable Drainage Systems (SuDS). SuDS attempts to manage surface water drainage systems holistically, in line with the ideals of sustainable development. It aims to design for water quantity management, water quality treatment, enhanced amenity, and the maintenance of biodiversity. In so doing many of the negative environmental impacts of stormwater are mitigated and some benefits may in fact be realised. This study set out to identify and develop new and appropriate guidelines for the use of alternative stormwater technology in South Africa. The project resulted in the development of the following knowledge products:

- Sustainable Drainage Systems – South African case studies.
- The South African Guidelines for Sustainable Drainage Systems (The South African SuDS Guidelines)
- The 'SuDS Economic Model (SEM)'
- The 'SuDS Conceptual Design' poster
- The'Working Sustainable Drainage Systems into the City' poster
- The 'Water Sensitive Urban Design: South Africa' website (www.wsud.co.za)

There is unfortunately limited experience and data available locally; therefore the parameters quoted in this guideline have all been collected from international literature. These parameters are dependent on a variety of factors including, inter alia, climate, pollution composition and concentration, technical design, and maintenance. Local conditions should thus be carefully considered before the use of these values.

Cost: R1 800 000
Term: 2008 - 2012

Improving sewerage for South Africa
University of Cape Town; City of Cape Town; eThekwini Municipality
No. 1827

Informal dwellings tend to be laid out in a manner that is not conducive for retrofitting drainage according to conventional engineering standards. Coupled with unfavourable ground conditions (ranging from settlements in flood-prone areas to discontinued landfills), retrofitting and/or installing conventional sewerage in such conditions is inherently problematic, particularly in situations where residents refuse to relocate (even temporarily) for fear of further

marginalisation. Alternative approaches to providing sewerage to informal settlements were investigated in order to determine whether there are other means of providing these areas with low-cost wastewater collection systems. This report builds on South African research into alternative sewerage systems (Du Pisani, 1998a, b; Eslick and Harrison, 2004; Van Vuuren and Van Dijk, 2011a, b) by presenting the outcome of their utilisation and management in three Western Province applications: simplified sewers and vacuum sewers in two Cape Town informal settlements and settled sewers in the formal areas of Hermanus. The progress in planning a pilot settled sewer project for the Cape Town informal settlement of Barcelona is also presented. The four case studies reported upon in the document endeavour to illustrate a variety of socio-political and risk factors that cause sanitation facilities and projects to succeed or fail, especially in informal settlements. A significant amount of 'best practice' literature and discourse was also reviewed on how best to develop alternative sewerage schemes and participatory approaches as a means to possibly improve urban sanitation conditions in South Africa's high-density informal settlements. More cost-effective and flexible sewerage than conventional systems are needed to sewer South African informal settlements, and this need can potentially be met through alternative technologies such as simplified, settled or vacuum sewerage. These technologies are technically proven to work elsewhere in the world; however, the South African research to date has reached the conclusion that the ability of sewers to function as designed is closely related to how sanitation technologies are planned, managed and used. In other words, the social processes that underlie the planning, provision and management of sewerage systems are just as significant as technology choice.

Cost: R1 500 000
Term: 2008 - 2012

Programme 5: Sanitation technology and innovations

Evaluation of the bucket eradication programme
Hlathi Development Services; Tshwane University of Technology
No. 2016

In February 2005, the bucket sanitation backlog in formal townships was estimated at 252 254 buckets (DWAF, 2006). According to the Department of Water Affairs' closing out verification report of the bucket eradication programme (BEP), between February 2005 and December 2007, the national Government allocated a total of R1.8 billion for the BEP (DWA, 2009). The majority of municipalities used the conventional waterborne sanitation system to replace buckets in urban formal settlements. This presented a challenge for municipalities servicing areas without bulk sewers and inadequate wastewater treatment capacity, and in some cases the available water supply could not support the new waterborne sanitation systems. This study was initiated to assess what worked and what did not work, to evaluate the extent of compliance of the bucket eradication programme (BEP) with sanitation policy principles and the impact of the BEP on quality of life for the beneficiary communities. The BEP case study municipalities failed to comply with most of the sanitation policy principles. The found that the supply-driven approach adopted in the implementation of the BEP failed to plan for sustainable sanitation service delivery because it focused on toilet construction. This led to poor performance of wastewater treatment works which were assessed as part of the study because no resources were allocated to the proper operation and maintenance of new or upgraded WWTWs. The BEP put limited emphasis on hygiene awareness, community involvement and user education.

Cost: R920 000
Term: 2010 - 2012

Evaluation of the user acceptance and functioning of mobile communal sanitation facilities – a case study of Cape Town
Cape Peninsula University of Technology
No. 2017

Technical innovations often lack sustainability due to a lack of attention to or provision of operational requirements and community involvement. The application of sanitation technologies in informal settlements lacks a framework for introducing and assessing the performance and functioning as well as an understanding of the perspectives of end-users of the new technology, despite the existence of the national Strategic Framework for Water Services. This general framework does not clearly define 'basic sanitation' in terms of technology. This research was initiated to deal with this problem by investigating the current approaches to the implementation of a new sanitation technology, and the acceptance and functioning of the technology in the natural setting of informal settlements. The study concludes that the MCSF can adequately function in the context of informal settlements (IS), provided strict observance of each phase of the framework's criteria and associated indicators. The functioning of MCSF is context based and depends on user's demand for sanitation, compliance with operational requirements and the extent of O&M (with regard to the way reported issues are responded to). The high level of user's acceptance of the facilities registered through the application of the framework and the adequate functioning of the facilities are aligned with the research hypothesis, except for the planning phase of the functioning. For this phase of the framework, the research has shown that adequate functioning of the facility is influenced by the demand for sanitation and appropriate design is only a secondary issue.

Cost: R716 750
Term: 2010 - 2012

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 2: Integrated management

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex
CSIR, University of Stellenbosch; Eco Innovation, University of Cape Town; University of KwaZulu-Natal (Durban), University of Stellenbosch, No. 1833

This project looked at the key factors that influence the environmental sustainability of a large inland industrial complex, the Secunda Industrial Complex. The main finding for this study is that the long-term increasing trend for unaccounted salt flows to the surface water systems indicates control of salt storage and disposal is the key factor for environmental sustainability. The economics of desalination and waste storage are driven by the cost of water and the management of post-closure liabilities. These two parameters are controlled in the governance system for clean water conservation and mine-water production, which is the main source of salts. A key weakness in the governance component appears to be the absence of public data on relative techno-economic and environmental performance for alternatives identified by stakeholders in the complex. Research is currently system-specific, proprietary and therefore uncoordinated. Findings on capacities and leakage are not reported in the public domain.

Lessons from this project indicate that the problems of technology selection and economic viability are less complex when there is a sustainable economic plan to eliminate uncertainty on post-closure liabilities, and a set of technologies that can be made to work using a purchase contract for the recovered water. The main environmental uncertainty appears to be around the long-term stability of the salt storage systems. The systems were established under a different regulatory framework which had a much lower concern for water shortages, long-term salination and decanting of acid mine water. Definitive guidelines on salt storage and post-closure management of the salt stockpiles have not been developed and subjected to the scrutiny of public review. This appears to be a key barrier to the quantification of environmental and economic sustainability. The key sustainability problem is how to reverse the trends of positive feedback on the salt storage problem. Another concern is the increasing trend in salination and risk of AMD pH-dependent river flows.

Cost: R3 000 000
Term: 2008 - 2011

Programme 4: Governance, policy, regulatory, and economical instruments to improve industrial water management

Protocol for quantitative assessment of industrial effluents for discharge permitting
University of KwaZulu-Natal (Pietermaritzburg); University of the Cape Town; Durban University of Technology; eThekwini Water and Sanitation; Sasol; University of Ghent
No. 1734

The major elements that the local authority has for managing industrial wastewater are its wastewater treatment plants for remediation, discharge permits for placing limits on what may be discharged, and a discharge tariff for financing the treatment and for providing a set of incentives and penalties to influence users of the system. An effluent discharge permit consequently is a crucial interface between the local authority and an industry, and the permit system has to carefully balance protection of the general public and the environment against the rights of those working in industry and the promotion of economic activity. The activated sludge process is the most common form of treatment for municipal wastewater in South Africa. In many of South Africa's WWTP's, an industrial wastewater fraction is accepted for treatment with domestic sewage. However, no biological or modelling approach is currently used to estimate impacts and, therefore, set limits on discharge. Hence, the conceptual basis of this project was to develop a protocol, involving a combination of laboratory testing and process modelling, which would be able to predict the effect of a range of loads of factory effluent on the operation of the treatment plant receiving its effluent, to inform the process of granting a discharge permit. Due to the sustained high impact of textile effluents on several WWTPs in eThekwini, textile effluents were chosen as the subject of all of the investigations. Baseline models were developed for two WWTPs in the eThekwini Municipality: Mariannridge and Verulam. Both were selected because they received a significant proportion (approximately 30% by volume) of industrial effluent, and because they experienced significant problems associated with textile effluent, primarily high colour and conductivity. Several series of tests were carried out to establish a methodology for assessing the biodegradability of surfactants using the OUR apparatus. However, the project faced several challenges: Characterisation of the incoming wastewater proved to be the major difficulty in both investigations.

Attempts to transfer the OUR measurement techniques to municipal staff met with very little success. This was partly due to the problems with the reliability of the technique, but also the unavailability of technical staff with the required level of skill, patience and time to devote to such a time-consuming measurement. Thus, although the project was motivated by a perceived need of the municipality to develop a more scientifically defensible basis for setting permit limits, there seems little chance that they would be able to implement such a complex protocol in-house for the foreseeable future. The obvious alternative would be to set up a specialist consultant service, with integrated laboratory and computational capabilities.

Cost: R1 600 000
Term: 2007 - 2013

Evaluation of partitioning coefficients for South African soils to inform the new National Framework for the Management of Contaminated Land with emphasis on the protection of water resources
Golder Associates Africa (Pty) Ltd;
University of Pretoria
No. 2102

Appropriate screening is imperative to the registration of contaminated land and has significant implications for industry, government and the environment. Inappropriate screening during initial investigations will result in some constituents and sites being screened for further detailed assessment and registered as contaminated land on the basis of naturally-occurring soil concentrations. On the other hand, some constituents and sites that pose a potential risk may appear uncontaminated while further investigation is actually warranted. A high degree of uncertainty therefore exists in screening soils for further assessment and registration as contaminated land. The aim of this study was to address a number of uncertainties and to assist in refining the norms and standards for the assessment of contaminated land. Following the results obtained from this investigation, the following is recommended: The 1:2.5 soil:solution ratio extract should be used to estimate the pore water quality of soil. This is also the standard method used for the determination of soil pH(H_2O) and therefore considered as an acceptable method and easily implementable by commercial laboratories. Based on the Kds determined in this study for 10 different diagnostic South African soil horizons, preliminary additional soil screening values could be calculated which are specific for certain soil types. However, the SA baseline concentrations for natural soils were also considered. Based on these calculations, soil types were grouped together and preliminary risk-based soil screening values (RBSSV) were established which can be used during Phase 1 contaminated land assessments. During Phase 2 contaminated land assessments, where more information will be available on soil type and properties, the Kds can be used to further refine the soil screening values for specific soil types/horizons. Vertic soils, red oxidic soils with high clay content, melanic soils and gley soils can have higher soil screening values for Cu and Pb, since these soils have a strong sorption capacity and the risk for groundwater contamination will be less. The Kds determined during this investigation showed a strong correlation with soil pH and therefore soil pH can be used to refine the Phase 2 soil screening values. Preliminary recommended pH-specific SSV (pH-SSV) for Cu, Pb and V were calculated which can be used during Phase 2 contaminated land assessments.

The potential risk that a contaminant may pose to groundwater can be assessed by determining the soluble fraction of the contaminant in the soil. A 1:2.5 deionised

water extract can be conducted on soil samples during the Phase 1 screening level assessment and the results can be compared to the Water Quality Guidelines for the specific contaminant to indicate potential risk for groundwater contamination.

Cost: R480 000
Term: 2011 - 2013

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Pilot application of a dual stage membrane bioreactor for industrial effluent treatment
Alt Hydro cc; Dekker Envirotech; Cape Peninsula University of Technology; North-West University (Potchefstroom)
No. 1900

This project investigated the application of the dual-stage operations strategy in a pilot plant evaluation of a membrane bioreactor (MBR) for the on-site treatment and recovery (reuse) of industrial trade effluent. The goal of the study was to use the MBR system as a pre-treatment for the reduction of the wastewater pollution load so that a downstream reverse osmosis (RO) system can be incorporated to facilitate a zero-liquid discharge strategy as well as effluent reuse potential for the industrial partner. A textile manufacturer located in the Western Cape was chosen as one of the industrial partners for the on-site evaluation of the pilot plant. A 5 to 10 m^3/day MBR pilot plant incorporating sidestream Airlift™ membrane modules was designed and was operated on-site from March to December 2010. The design of the dual-stage MBR process was geared towards optimal microbial community enrichment and was based on a pre-denitrification configuration coupled with enhanced biological phosphate removal (EBPR) (anaerobic-anoxic-aerobic with recycle loops). The anaerobic-anoxic-aerobic process was designed to incorporate two primary functionalities: influent azo dye cleavage in a reducing environment followed by oxidation of the resultant aromatic amines; and biological nutrient removal through enrichment of associated microbial consortia using nitrification, denitrification, and phosphate removal processes. To achieve this, the preliminary data analysis was used to identify critical scale-up criteria. In terms of overall results, COD removal fluctuated considerably during the 3-month start-up stage (~100 days); thereafter, an average of 90–95% removal was achieved under optimised conditions. When compared to the South African Government discharge standard for COD (≤ 5 000 mg/L), the COD value for the treated textile effluent (20 mg/L) was well within this standard. A paper and pulp industry located in the Western Cape was also chosen as an industrial partner for the evaluation of a pilot-scale MBR plant for the treatment of paper mill effluent. A 45–65 L/day MBR pilot plant incorporating ceramic membranes in an external modular configuration (similar to the sidestream Airlift™ membrane modules) was designed and was operated in a laboratory from June to December 2010. The design of the dual-stage membrane bioreactor was based on a pre-treatment high-rate anaerobic system (EGSB) coupled with a post-treatment denitrification/nitrification configuration (anaerobic-anoxic-aerobic with recycle loops). The high-rate anaerobic process was designed to reduce influent COD in an attempt to reduce the need for high volume dosing. The anoxic-aerobic processes were designed to incorporate two primary functionalities: further reduction of COD concentration; and biological nutrient removal through enrichment of associated microbial consortia using nitrification and denitrification processes. In terms of effluent COD reduction efficiency,

the anaerobic pre-treatment stage gave an average of 70% COD removal while the MLE-MBR stage increased the total COD removal to 97%.

Cost: R950 000
Term: 2009 - 2011

Recovery and beneficiation of nutrients, water and energy from brewery effluent by means of algal assimilation, hydroponics and aquaculture
Rhodes University; Department of Water Affairs; Dames
No. 2008

The HRAP/wetland system is an environmentally sustainable method of treating brewery effluent that allows for the recovery of water and nutrients from the wastewater. It is a low-energy, low-maintenance system (both biologically and physically), driven mainly by gravity and the sun's energy. The only external energy inputs for the HRAP system were two small (0.45 kW) motors that drove the paddlewheels. As such, the cost to build and operate the system could be recovered quickly and the potential exists to recover these costs even faster if the water and nutrients that are recovered are reused or sold. The HRAP and wetland system consistently brought most water quality parameters tested here to within or close to the DWA general limits for the discharge of industrial effluent into a natural water resource. A model was developed that made it possible to predict the success of this system under various conditions that might be applied to other industries. Furthermore, the treatment/recovery process involved the production of downstream products such as algae, fish feed, fresh vegetables and healthy fish. This programme also saw the first attempt at optimising the use of industrial effluent as an inorganic source of fertiliser for hydroponic vegetable production. Fish and vegetable production can take place using post-HRAP water, or water that has been subject to both HRAP and CW treatment. The CW did not require pre-treatment in the HRAP and operated more efficiently when HRAP was not included in the treatment chain; however, it was not possible to exclude the primary facultative pond (PFP) prior to treatment in the CW. The advantage of the wetland is that it is entirely self-sustaining but is difficult to clean/recharge, may clog up over time and takes more time to commission, whereas the HRAP can be inoculated and fully functional within days. The downside of the HRAP/CW system is that it takes up considerably more space than conventional methods of water treatment, such as activated sludge systems, for example. The estimated area required to treat 1 000 m^3/day of post-AD brewery effluent is probably around 1.4 to 2.0 ha. However, with improved efficiency and optimisation this footprint might be further reduced. The programme has successfully demonstrated that industrial effluent, which is currently considered a costly liability by most industries, can be turned into a job-creating, income-generating stream, using simple technologies that have been available for years.

Cost: R1 798 000
Term: 2010 - 2013

Development of hybrid membrane-chromatography system for simultaneous recovery of valuable products and water purification for recycle in the olive Industry, with a view towards commercial application thereof
University of Cape Town; African Biological Extracts (Pty) Ltd; Cape Olive Trust (Pty) Ltd; Ikusasa Water (Pty) Ltd; Moss Group cc
No. 2010

Olives are exceedingly bitter and need to be cured to make them palatable before consumption. The curing process involves placing the olives in a brine solution whereupon a spontaneous lactic acid and/or yeast fermentation takes place. The brining process takes from 3 to 12 months, and is associated with various washing and rinsing steps. This results in noxious darkly-coloured and acidic wastewaters with a high organic load (COD < 70 g/L, high phenolic content (< 5 g/L), and high salinity (~10% NaCl, three times more than seawater). It is a water-intensive process; up to 10 kL of water is consumed per ton of olives processed. The wastewaters generated present an environmental disposal problem, as they are not amenable to biological treatment, and cannot be disposed of in municipal sewage systems or the environment for toxicity reasons. They are generally disposed of in evaporation ponds. A modular treatment system was successfully designed, constructed and operated in order to process wastewater brines from the table olive industry. The system was comprised of two main unit operations: membrane separation and chromatographic adsorption. These two sequential unit operations were able to simultaneously produce purified brine for recycling back into the table olive process, and recover high-value antioxidants which would otherwise have been discarded. In addition, the volume of wastewater for final disposal was significantly reduced. The process can be considered to be green, as no environmentally harmful or toxic chemicals were used or produced. Despite lower than anticipated yields and productivity in terms of antioxidant recovery, the project was considered overall to be a success. The membrane system operated adequately in terms of separating the darkly-coloured high molecular weight phenolic components from the brine, which was then treated by the chromatography system to produce purified brine for recycle. The purified brine was good quality and was deemed to be suitable for re-use. Overall process performance and economic feasibility of the system was evaluated. While not optimal, based on market analysis there is a strong case to be made for continued and improved operation of the system, and for subsequent increase to full-scale operation. In this regard a spin-out company is to be created in order to exploit the technology developed during the course of the project.

Cost: R892 000
Term: 2010 - 2012

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 3: Minimising waste production

Preparation of magnetic nano-composite beads and their application to remediation of mine wastewaters

University of the Witwatersrand
No. 2014

In this study, magnetic ion- imprinted polymers with high recognition for uranyl (UO_2^{2+}) and chromium Cr(VI) ions were prepared for the first time. The prepared magnetic ion-imprinted polymers were characterised and optimised in the laboratory. They were then applied to wastewaters from acid mine drainage and influent from a wastewater treatment plant. The optimum extraction parameters in batch format for magnetic ion-imprinted polymers for uranyl ions were found to be: sample pH of 4, and 50 mg of magnetic ion-imprinted polymers for a 25 mL sample volume. The optimum contact time was found to be 45 min at a stirring speed of 1 500 r/min. The lower maximum extraction time implies that the magnetic ion-imprinted polymers have fast binding kinetics. Under these

optimum conditions, the recovery of uranyl ions was found to be above 80%. The binding of uranyl ions on the magnetic ion-imprinted polymers was found to follow pseudo second order kinetics with rate constant (k_2) and correlation coefficient (R^2) ranging from 0.273 to 0.678 and 0.9811 to 0.9992, respectively. This implied a chemisorption interaction of the uranyl ions with the magnetic polymers. The adsorption of uranyl ions onto the polymers fitted both Freundlich and Langmuir models. The maximum adsorption capacity was found to be around 1.2 mg/g which is in the same range as other magnetic ion-imprinted polymers but lower than other ordinary polymers or imprinted polymers without magnetic ions. Despite low binding capacity, the prepared magnetic ion-imprinted polymers, when tested for selectivity, were found to have superior selectivity for uranyl ions compared to major competitors of Fe^{3+}, Pb^{2+}, Ni^{2+} and Mg^{2+}, ions that have similar ionic radius. The selectivity order observed was as follows: $UO_2^{2+} > Fe^{3+} > Pb^{2+} > Ni^{2+} > Mg^{2+}$. The same selectivity and recovery was observed when the magnetic ion-imprinted polymers were applied to wastewaters from acid mine drainage and influent from wastewater treatment plants. The optimum extraction conditions for the prepared magnetic ion- imprinted polymers for Cr (VI) were found to be as follows; sample pH of 4, adsorbent amount of 20 mg for a 25 mL sample volume. The extraction time was 40 min at stirring speed of 1 500 r/min. The low extraction time indicates fast binding kinetics of Cr(VI) to the prepared polymers. At optimum conditions, the recovery of Cr(VI) was above 80%. The maximum adsorption capacity for the magnetic polymers was found to be 6.20 mg/g. The optimum time for the adsorption of the Cr (VI) analyte was determined as 40 min at stirring speed of 600 r/min. The binding of Cr(VI) on the magnetic ion-imprinted polymers was found to follow pseudo second order kinetics. This implied a chemisorption interaction of the Cr(VI) ions with the magnetic polymers. The adsorption of Cr(VI) onto the polymers fitted neither Freundlich nor Langmuir models. The prepared magnetic ion-imprinted polymers were found to very selective towards Cr(VI) compared to SO_4^{2-}, F^- and NO_3^-. The order of selectivity of anions followed the trend: $Cr_2O_7^{2-} > SO_4^{2-} > F^- > NO_3^-$. The prepared magnetic materials may not be suited for remediation of polluted wastewater for uranyl and Cr(VI) ions on a large scale because of high cost of preparing them but are very good as sample extraction materials before final quantification. This is very important because direct analysis of these metal ions from wastewaters is a huge challenge because of other interfering ions. Since the materials can be reused more than six times, this makes them inexpensive for sample extraction purposes.

Cost: R378 500
Term: 2010 - 2013

Evaluating approaches to and benefits of minimising the formation of acid mine drainage through management of the disposal of sulphidic waste rock and tailings

University of Cape Town; Imperial College London
No. 2015

The ideal approach to handling of sulphidic waste rock is to prevent the potential for generation of acid rock drainage (ARD) through the removal of the sulphide phase before its disposal, thus avoiding the need for long-term mitigation strategies. In the best case, this processing of waste rock prior to disposal should result in an increase in the recovery of values from the starting material and the re-allocation of waste materials as feedstocks for other uses. This report focused on the goal of establishing feasible approaches for the prevention of the formation of ARD from mining wastes by the removal of the risk rather than its delay.

Current ARD prevention strategies focus on covers and coatings. While these are effective, the life span of their effectiveness remains in question. The potential for the removal of sulphides from tailings was demonstrated in WRC Report No.1831/1/11, using tailings and waste rock from a base metal operation as a model system. The removal of sulphide by both separation and by reaction was demonstrated for the tailings and waste rock respectively, with the former showing the most promise. In this report, the general application of sulphide removal by separation to reduce the risk of ARD generation is presented across tailings and finely-divided mineral wastes from various sources, including a variety of coal fines and tailings from the gold industry. Demonstration of the removal of sulphide is presented with the associated reduction in potential for ARD generation. Further, the cost implications and disposal routes for the sulphide and benign fractions removed are considered. With respect to removal by reaction, accelerated bioleaching has, to date, shown limited value; however new approaches, using a broader spectrum of reaction systems, have been highlighted for further study. To extend this work, it is necessary to recognise the need for both acceleration of the reaction of sulphide under controlled conditions as well as deceleration or closing off of these reactions by restricting the supply of reactants through restricting access of water, oxygen, leach agents as well as microbial colonisation. The closing off of these reactions may be a treatment in itself or may follow the accelerated reaction to remove readily reactive sulphur. The role in waste rock dump characteristics, including permeability, as a means to manipulate this is addressed. An experimental study was conducted to establish methodology and provide proof of concept of the 'mingling' approach through analysis of flow. The impact of flow rate on colonisation and leaching was also studied experimentally. Recent studies on the removal of sulphide from tailings by separation were reviewed. This demonstrated that significant strides forward, independent of this study, have not been reported in the open literature since the publication of WRC Report No. 1831/1/11. In this study, we have extended the sulphide removal studies to a range of finely divided materials, including the tailings from the preparation of pyritic gold ore concentrate, the BIOX® tailings, and coal fines. In addition to demonstrating the preparation of the bulk of the material for disposal such that the ARD generation potential is small, potential uses for the residues are considered, as is the process costing. Using a series of five samples of coal fines, the proof of concept was demonstrated of sulphide removal from the bulk of the waste tailings by separation, in this case flotation, in order to eliminate or decrease ARD generation potential. Further, it was demonstrated that biodegradable oleic acid was an excellent collector, yielding improved performance over dodecane. A similar study on tailings from the gold industry has illustrated mixed results. Using flotation to upgrade the tailings from the laboratory, bioleaching of pyritic gold concentrates has been successful with decreased sulphide grades reporting to the bulk tailings. Here ARD generation potential was reduced but not eliminated as with other mineral systems. On treatment of the tailings (collected from the tailings dam) from the concentrator circuit by further flotation, no significant upgrading was achieved; however the sulphide associated with the solid tailings was already low. The study of gold tailings samples was limited by those samples attainable. It is recommended that further representative samples be sourced for study to further assess the generalised nature of the findings. Potential uses for both the sulphide-rich and sulphide lean tailings samples have been identified and illustrate a range of potential applications. In order to establish a framework for the economic costing of the sulphide removal from tailings and fine waste materials, a flotation desulphurisation flowsheet has been proposed to follow

the traditional coal processing flowsheet. This has been used as the basis for an order of magnitude estimate of a new fine coal desulphurisation plant using flotation and performance estimates. Based on assumptions specified, this preliminary costing has suggested potential for economic viability. A sensitivity analysis is presented which targets, among others, value of the resource recovered, yield and reagent costs as key considerations for optimisation of the approach.

Cost: R1 435 250
Term: 2010 - 2013

Programme 4: Mining in the 21st century

Nanotechnology in water treatment
University of the Western Cape; Wroclaw University of Technology; University of Stellenbosch; Cape Peninsula University of Technology
No. 1897

Zero valent nano-iron, zeolites, ordered mesoporous carbons, electro-deionization, an electrohydraulic discharge reactor, and chemical vapour deposition were investigated and each was found to show great potential as an effective means to treat industrial wastes such as acid mine drainage (AMD) and brine. The full project report details experimental work ascertaining the effectiveness of integrating selected nanomaterials into six different remediation strategies for the treatment of model and real contaminated water samples. The waters included AMD from Gauteng and Mpumalanga, industrial brine effluents, dyes, and bacteria-laden water. Clays and zeolites underwent mild activation steps and were then shown to be effective in removal of ammonia and salinity from solutions. Zero-valent nano-iron successfully treated mine water, and a one step process (where the mine water is the source of iron) was the most effective option. Ordered mesoporous carbons were very effective as mercury sorbents after being modified with suitable functional groups. An electro-deionization cell was implemented as an effective system for removal of up to 1 500 ppm of the major cations from industrial brine. Model solutions and industrial brines were used to explore the exchange capacity of new membranes for their applicability in brine purification. An electrohydraulic discharge reactor incorporating supported titanium dioxide nanofibres was shown to demineralise dyes, and disinfect *Escherichia coli* spiked waters. The work has been patented. Lastly, a chemical vapour deposition method was used to synthesize titanium dioxide nanoparticles supported on carbon nanotubes (CNTs). The silver nanoparticles deposited on the titanium dioxide acted as electron acceptors, enhancing the charge separation of the electrons and holes, and that led to a transfer of the trapped electrons to the adsorbed oxygen during UV radiation.

Cost: R1 565 590
Term: 2009 - 2012

Extended investigations into recovery of water and salts from multi-component hypersaline brines using eutectic freeze crystallisation
University of Cape Town; University of the Western Cape; TU Delft; Cape Peninsula University of Technology
No. 2012

Hypersaline inorganic brines are generated by a number of industries, including mining operations, power generation and petrochemical refining. In addition, because of pressures on water resources, and thus further water recycling and reuse, these brines present an increasingly significant global problem. Brine management consists mainly of disposal to

lined evaporation ponds, which is both a costly and unsustainable solution. Viable brine treatment solutions do not currently exist, and thus there is an urgent need to both develop and implement such treatment options. Eutectic freeze crystallization (EFC) has been identified as a possible novel brine treatment method, but to date it has not been applied to multi-component streams such as brines. Therefore, the overall aim of this project was to investigate the applicability of EFC to the multi-component hypersaline brines produced by major South African industries. The first objective was to establish the thermodynamic and kinetic factors governing the operation of a sequential eutectic freeze crystallization process. The second objective was to summarise the effect of real brines compared to synthetic brines on the operation and control of a eutectic freeze crystallization process. For the third objective, the effect of impurities and contaminants on the ice product formed during a eutectic freeze crystallization process was investigated. For the fourth objective, the effect of impurities and contaminants on the ice product produced in an EFC process was investigated. The fifth and last objective was to investigate how operating temperatures affect the yield and purity of the final products formed in an EFC process. Four brines were studied overall: two from the coal mining industry (Brine 1 and Brine 2), and two different brines from the platinum mining industry in South Africa. The thermodynamic modelling software was able to predict and simulate the phase equilibria of a multicomponent aqueous system over a wide temperature range by estimating the standard state terms and the excess terms with the use of various thermodynamic models. This was an important step because the identities of the potential salts, the temperatures at which they would crystallize and the potential yields of the various products could be predicted before any experiments were conducted. However, the thermodynamics only offered an equilibrium prediction. It was only by investigating the kinetic aspects of the system that the identity, crystallization temperatures and yield of products under real operating conditions could be confirmed.

Cost: R1 571 490
Term: 2010 - 2013

Programme 5: Low-volume mined products

Development of an analytical sensor for the identification, quantification and detection of heavy metal pollution associated with precious metal refinery wastewater
CSIR; University of the Western Cape; Cape Peninsula University of Technology; Anglo Platinum Research Laboratories; Dublin City University
No. 2013

The use of fast, reliable and continuous monitoring techniques for water quality analysis has become essential. This project assessed the aquatic environment around platinum group metal mining, determining to what extent the aquatic environment has been polluted by these mining activities, and determined whether the current analytical tools and techniques used to analyse metals are adequate. Environmental water samples displayed low metal concentrations. Seasonal influences affected the diversity of taxa for the biota samples collected and the metal concentrations within these samples. High Ni, Pb and Zn concentrations were recorded and it is possible that these metals are released from the sediment-water interface. The concentrations in the biota and algae were low, indicating that mining activities had a low impact at the sampling sites. The August biota samples showed higher concentrations of Al, Fe, Ni, Zn and Pt than in November. This may be due to higher water flow during November 2010, since sampling was done during the rainy season. The

main focus of this project was the development of an electrochemical sensor for the identification and quantification of metals in environmental samples. The results showed that modifying the surface of a glassy carbon electrode with a bismuth film assisted in the stripping analysis of the $M(HDMG)_2$ complexes, with M as the PGM (Pd, Pt and Rh) and dimethylglyoxime (DMG) as the chelating agent. The results obtained for the evaluation of the sensor showed varying results. The pH, DMG concentration, deposition potential, deposition time and PGM concentration were optimised. The effect of interfering ions was investigated and Ni(II) and Co(II) were the main interferences. The limit of detection (LOD) was found to be 0.12 $\pm$ 0.06 µg/L for Pd, 0.04 $\pm$ 0.007 µg/L for Pt and 0.23 $\pm$ 0.04 µg/L for Rh. The ranges to which the sensor can be applied were 0.1 to 3.5 µg/L for Pd, 0.5 to 4.0 µg/L for Pt and 0.1 to 4.0 µg/L for Rh. The sensor was successfully applied in the determination of Pd, Pt and Rh in freshwater and sediment samples.

Cost: R716 000
Term: 2010 - 2012

THRUST 6: WATERSMART FUND

Programme 1: Watersmart fund

In-field demonstration of a remote, real-time water quality monitoring system
CSIR; Prime Africa Consultants
No. 2196

The aim of the project was to supply data in real time to municipalities so that they could better manage their wastewater quality. Initially pitched as a field trial at one remote rural WWTW, the interest and opportunities provided by eThekwini Municipality prompted the change to the selection of four WWTWs in that municipality, and the project was implemented at the Kingsburgh, Verulam, Mpumalanga and Amanzamtoti WWTWs. The WQMS stations were installed in August and September 2012 and six months of data was collected by the stations. Despite some challenges in installation and station operation, the sampling and data communication is now stable and reliable. The team was able to develop a comprehensive maintenance manual and identify the appropriate channels and methods of knowledge transfer. The study showed that the accuracy of the data collected and transmitted is unreliable, as evidenced by the variation from laboratory results (both CSIR and eThekwini) and the variation of probe readings between calibrations. For this reason, beyond an introduction to the online reporting system and an illustration of use, it was not shared as a functioning system for the four eThekwini WWTWs.

Cost: 250 000
Term: 2012 - 2013

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Strengthening the sustainability and effectiveness of Free Basic Water
Counterpoint Development
No. 1989

There is growing recognition across South Africa of the pivotal importance of sustainability in water services provision: sustainable funding and revenue to support ongoing service delivery, sustainable water resources

management to meet current and future demand, and sound operation and maintenance of all associated infrastructure to sustain continuous provision of potable water to citizens and key sectors of the economy. But does provision of Free Basic Water support or undermine sustainable provision of water services? The need to provide support to households living in poverty to enable them to access at least basic water services affordably is not in question. But how sustainable is the provision of Free Basic Water, as currently implemented, if it sends out mixed messages about the real value of water in a context of growing scarcity, and if it is contributing to operating shortfalls in municipal revenue arising from unbilled water? What are the trade-offs in the current approach? Are there more effective ways of achieving the desired outcome of ensuring that even the poorest citizens can afford at least basic services? There is growing evidence that the administrative and financial requirements for providing Free Basic Water and Sanitation sustainably to those who need it have been underestimated. Free Basic Water is at risk of becoming increasingly anti-poor, because many municipalities lack the capacity to implement it effectively or sustainably, are not able to manage their available funds optimally, and are funding service provision through under-spending on operation and maintenance. Inevitably these weaknesses compromise the quality of service provision, and it is the most impoverished households who are impacted most. In a context of chronic poverty, limited administrative capacity in many municipalities, and growing water scarcity, is the provision of Free Basic Water the most effective and sustainable way of giving force to the Constitutional right of access to adequate water? This study aims to review international good practice around financing water services and designing water tariffs for sustainable water servicing and to review approaches and funding mechanisms adopted by relevant middle-income developing countries with substantial poor populations to providing affordable water services to needy and vulnerable citizens.

Estimated cost: R1 400 000
Expected term: 2010 - 2012

Mechanism for pricing and financing the implementation of the Green Drop Report to guide the strategic decrease of the risk factor of wastewater treatment works
Asset Research
No. 2085

During 2010 the Department of Water Affairs published its 2009 Green Drop Report. Only 32 of the 852 wastewater treatment plants obtained a Green Drop award, i.e., were considered to have performed and achieved a delivery of service at acceptable risk levels. It was found that most facilities in the rural areas and smaller towns are not adequately equipped with staff of appropriate skills and this constrained the performance of these systems in their overall Green Drop assessment. While the report wishes to promote incentive-based regulation and acknowledge excellence in wastewater quality management, it neither reflects on the financial cost and resources required for achieving this nor on the economic costs and implications of not achieving the desired turn-around in waste management and improvement in performance of the wastewater treatment works. This study wishes to address these issues

Estimated cost: R597 500
Expected term: 2011 - 2013

Providing water services at tariff levels that cover cost and that are sensitive to demand
Nelson Mandela Metropolitan University
No. 2087

The benchmarks for municipal water service provision in South Africa have been set nationally and with reference to the level of income of the community – with a better service being provided to the well-off sections than to the poor. Historically, those users who were required to pay for the cost of providing the service were concentrated in relatively small urban areas. The tariff structure they faced was flat and determined with reference to a diverse range of accounting principles and practices. The burden of covering the cost of provision was averaged for the well-off users, proportional to use. More recently there have been several important changes – an increase in the level of high-standard service provided to the poor (towards a uniform service for all) and a movement away from a flat tariff structure to an increasing block tariff. This project proposes to contribute insights on the latter issue. There are many relevant questions in this regard. Does existing pricing policy incorporate the full financial costs of managing water? Are economic costs taken into account in the pricing of water services?

Estimated cost: R1 250 000
Expected term: 2011 - 2014

Programme 2: Institutional and management issues – Water services

Adapting and piloting the new concepts of Community-Led Total Sanitation (CTLS) in the South African municipal environment
Cape Peninsula University of Technology
No. 2088

Community Led Total Sanitation (CLTS) focuses on behaviour change rather than toilet construction. CLTS mobilises a cooperative approach based on people deciding together how to create a hygienic environment that benefits everyone. Total sanitation ensures that everyone uses a hygienic toilet and safely disposes of their domestic waste, creating a safe and clean environment. The CLTS approach encourages responsibility by the community, taking its own action. Cooperation among households is a key element, as is spontaneous emergence from within communities of 'natural leaders' (NLs) as facilitators. The objective of this study is to adapt and test the concepts of CLTS in the South African environment and context.

Expected cost: R2 500 000
Expected term: 2011 - 2014

A comparative analysis of water management devices in Cape Town and prepayment meters in Johannesburg
University of the Western Cape
No. 2089

South Africa has made great strides in improving access to water supply. Many poor people previously supplied with water, and those with new connections, face the grim reality of water un-affordability, exacerbated by the installation of prepaid meters and water management devices. Yet it has also been argued that the unwillingness of water users to pay is a remnant of anti-apartheid rent boycotts. This study aims takes the debate on water metering technology and cost recovery methods further. It seeks to expose the differing experiences of two major technologies used in South Africa – prepayment meters and water management devices which are ostensibly different. While these technologies may operate differently on the surface, it is likely that their effects are the same.

Estimated cost: R500 000
Expected term: 2011 - 2013

Programme 5: Water services education and awareness

Social norms and moderation of water consumption in a major South African city
EPRU
No. 2091

South Africa has a fairly limited supply of water. This supply of water is coming under increasing strain as democracy and economic growth have seen the water consumption of a growing number of South Africans increase, as their livelihoods improve and basic services are extended ever further. Much of this increased consumption is occurring in South Africa's large cities, Johannesburg, Durban and Cape Town, where the greatest share of South Africa's growing businesses are located and which are consequently the epicentres of growth and magnets for people migrating within the country. This study proposes testing a demand-side management strategy, based on reporting comparative social norms for water consumption, within one of South Africa's major cities' households and businesses. The strategy is to test the process of people making decisions based upon information that is reported in a particular fashion, rather than upon contexts such as price increases or slow roll-out of basic services.

Estimated cost: R462 000
Expected term: 2011 - 2013

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Application and performance of slow sand filtration
Cape Peninsula University of Technology
No. 1836

Slow sand filtration is generally highly recommended in small and rural community water treatment because of its simplicity in design, operation and maintenance. However, little awareness of the application of slow sand filters exists in South Africa. Very little is further known about the slow sand filters in operation in South Africa and how they are performing. The project, therefore, aims to investigate the extent of slow sand filtration applications in the country and practical performance of these filters, covering both successful and failed examples. It will also investigate and document the types, application and performance of the various pre-treatment processes prior to slow sand filtration. A database of all sand filtration plants in the country will further be compiled.

Estimated cost: R760 000
Expected term: 2008 - 2011

Wastewater reclamation for potable reuse
Umgeni Water
No. 1894

Water is a scarce resource, especially in South Africa where runoff exceeds rainfall and is unevenly distributed. South Africa has been classified as water stressed and water should therefore be conserved. The pressure exerted on surface and groundwater supplies should be reduced or at best maintained, rather than increased

as the country's human population and industrial development increase. Wastewater reuse offers such a possibility, and reclaiming domestic wastewater from Darvill Wastewater Works for potable reuse using membrane bioreactor technology is therefore being investigated. This project is intended to pave the way for technology enabling South African water suppliers to produce consistent, acceptable drinking water quality through used-water reclamation. Initial feasibility work will be followed by a demonstration plant designed and operated over a long-term trial to establish operating guidelines that ensure reliable product water will be generated at all times.

Estimated cost: R650 000
Expected term: 2009 - 20112

Development of design and operating guidelines for high-rate clarifiers in the South African water treatment industry
Umgeni Water
No. 1942

High-rate clarification is a relatively unexplored technology in South Africa, even though this technology is being used extensively abroad. There is only one known water treatment plant using high rate clarification in South Africa, i.e., the Bethlehem Water Works (a review of the performance of this plant is included as part of this project). This technology is not as widely used in South Africa as it is abroad due to poor marketing and a poor fund of knowledge on this technology. In conventional clarifiers, clarification rates of 1.0 m/h to 4 m/h are generally used, whereas in high-rate clarification processes clarification rates as high as 10-30 m/h can be achieved. With the increased cost of construction and especially the doubling of the price of steel over the last year, it is critical that structures with smaller footprints, using 10-20 times less steel and concrete be critically considered in future designs. As a typical example, a 4 m diameter clarifier operating at an upflow rate of 10 m/h would produce 3 ML/d of treated water. In contrast a similar diameter clarifier operating at conventional upflow rates of 1.0 m/h would only produce 0.3 ML/d.

Estimated cost: R1 800 000
Expected term: 2009 - 20112

Programme 2: Water treatment for rural communities

Compilation of guidelines for the selection and use of home water treatment systems and devices
Tshwane University of Technology
No. 1884

At least 5.7 million people in South Africa still have no access to treated, potable water within reasonable distances from their dwellings and many thousands more take water from water sources and use it untreated because of problems experienced with adequate and reliable potable water supply. Surface waters have steadily become more polluted – especially with regard to microbiological quality, which exacerbates the situation of the immuno-compromised when drinking inadequately treated or poor-quality water. A number of home treatment systems and devices are being used internationally by small, rural communities without potable water services (decentralised systems). These units vary from the most simple – such as using material as filter – to the most sophisticated systems treating grey-water to potable standards. Although various systems and devices have been extensively reported on in the literature, and some exploratory work has been performed in South Africa, little is known locally about the existing options – and little has been done

to assist local communities or their advisers in making informed choices on whether such a system or unit will be appropriate to their situation, or which unit should be selected. This project will meet the need to source and investigate appropriate units, to determine their efficiencies of contaminant removal under local conditions as well as their sustainability potential, and to provide guidance on the selection and use of these units under local conditions.

Estimated cost: R1 200 000
Expected term: 2009 - 2012

Programme 4: Water distribution and distribution systems

Energy generation from distribution systems
University of Pretoria
No. 2095

In South Africa we are facing an energy crisis which places additional importance on the harvesting of all available feasible renewable energies. The initial scoping investigation highlighted the potential hydropower generation at the inlets to storage reservoirs, i.e., the bulk water distribution systems. In South Africa there are 284 municipalities and several of the water supply utilities all own and operate gravity water supply distribution systems which should be considered for small-scale hydropower installations. Most of these water supply/distribution systems may be equipped with the pumps as turbines, replacing the pressure throttling valves allowing for the hydroelectricity generation. The hydro-energy may be used in the own plant, supplied to the national electricity grid or used to feed an isolated electricity demand cluster. This study aims to prove that it is feasible and technically possible to generate energy from distribution systems.

Estimated cost: R2 500 000
Expected term: 2011 - 2013

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies– Preparing for the future

Mass balance modelling over wastewater treatment plants III
University of Cape Town; University of KwaZulu-Natal
No. 1822

The series of projects aims to develop a plant-wide wastewater treatment plant (WWTP) model used to accurately predict the outcome of the various biological, physical and chemical processes taking place in a WWTP. These tools can result in more economical wastewater plant design and operation and improved effluent quality. Significant advances have been made towards developing steady state mass balance-based integrated WWTP models which link primary sedimentation, nitrification-denitrification activated sludge and aerobic or anaerobic digestion of primary and waste activated sludges (K5/1338 and K5/1620). This project aims to determine the kinetics of P release from biological P-removal systems and determine the extent to which mineral precipitation takes place. The P release in anaerobic digestion will be compared to that observed in aerobic digestion. Certain aspects such as the mineral precipitation in aerobic digestion, the un-biodegradable fraction of primary sludge and the un-biodegradable fraction of the waste activated sludge from nitrification-denitrification systems will be confirmed. The research will determine whether the presence of primary sludge will assist in the hydrolysis of waste activated in anaerobic digestion.

Estimated cost: R998 950
Expected term: 2008 - 2010

Effects of urine separation and treatment on wastewater effluent quality
CSIR (Stellenbosch); AFRICON;
University of Stellenbosch
No. 1824

The project deals with alternative sewage collection and treatment for both low and high income communities in urban settings. The concept includes the separate treatment of urine and the rest of the black/grey sewage to achieve better effluent quality. This project aims to demonstrate at pilot scale that the DWA Special Standards can be achieved through (partial) separate collection of urine. In addition, this increases the capacity of the receiving wastewater treatment plant which could delay extensions. The research will be reconfiguring toilets and urinals to allow (partial) urine separation on pilot scale. It will determine the composition of urine and demonstrate the effectiveness of treating wastewater with less urine than normal in varying quantities to achieve very low nutrient effluent concentrations (DWA special authorisation), as well as relatively low salt effluent concentrations. The study will assess the operational issues, such as struvite and other forms of scaling in urine drains, odours, etc. This project will assist in creating awareness for the potential positive impacts of urine separation and the feasibility thereof.

Estimated cost: R1 200 000
Expected term: 2008 - 2011

Biotech in sanitation: biopolymer production with *Natronococcus occultus*, a haloalkaliphile using municipal wastewater and other waste resources
University of Cape Town
No. 2000

Natronococcus occultus is a haloalkaliphile isolated from East African soda lakes, which are characterised by low Ca and Mg levels, with high Na, Cl and CO3 concentrations and a pH of 10-11. *Natronococcus occultus*, produces a glutamic acid-rich polymer, poly-glutamic acid (PGA). This polymer has a wide range of uses including hydrogels, flocculants and soil conditioners and may be used for medical applications. Preliminary work in CeBER (UCT) laboratories has shown more consistent growth in the high salt environment under non-sterile conditions. This project aims to study this organism using wastewater as a feed substrate to produce a biopolymer or environmentally friendly flocculants. It can also be cross-linked and blended with the treated sludge for a high-value soil conditioner. This project investigates the potential of municipal wastewater treatment plants to produce materials required by the plant for operation, from its own waste resources.

Estimated cost: R356 000
Expected term: 2010 - 2012

Co-digestion of sewage sludge and industrial concentrates
University of KwaZulu-Natal
No. 2001

The WRC has supported several laboratory-scale and feasibility projects on co-digestion of industrial effluent as a treatment strategy for toxic industrial wastes. eThekwini municipality has agreed to pilot full-scale

anaerobic co-digesters at Amanzimtoti WWTW. The digesters are expected to be refurbished in 2010. As a support to this initiative, this project will look at using WEST software to assist in building and transferring knowledge on operation and training needs. The investigation will be undertaken in six phases that will overlap with one another. The project will look to develop an in-line model of the laboratory-scale AD which will be followed by the development of an unsteady state model for the anaerobic digesters at Amanzimtoti WWTW. This will be used to predict performance of the full-scale digester. The WEST model will also be developed to analyse tests undertaken with selected industrial effluents in order to determine the parameters necessary for describing the kinetic effects of co-digestion of different feeding rates of the effluent. The model will be assessed for its ability to predict and test the performance of several industrial concentrates at once. The project will also investigate scenarios to maximise methane production or toxic effluent treatment and to demonstrate recovery from process upsets. Finally, the West model will be used to train the operational staff on how to react to different hypothetical upset conditions. If during the period of the project, upset conditions occur, data will be recorded so that a portfolio of case studies can be developed and procedures will be developed to determine the root cause of the upsets. Overall, this project will assist in developing a model to assist in the process control and training of support staff for the implementation of co-digestion at a full-scale AD.

Estimated cost: R1 050 000
Expected term: 2010 - 2012

Urban effluent treatment in a rhizofiltration system
Durban University of Technology; University of Stellenbosch; University of Cape Town
No. 2004

Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see

highly variable flow rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material are selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

Estimated cost: R2 400 000
Expected term: 2010 - 2012

The development of nanocomposite polysulphone membrane with reduced fouling properties for use in wastewater treatment
University of the Western Cape
No. 2006

Polysulphone (PSF) membranes are the most common membranes used in ultrafiltration of wastewater due to their mechanical robustness and structural- and chemical stability. Unfortunately PSF is a hydrophobic material, making its surface prone to fouling due to adsorptive mechanisms. Fouling can either be caused by cake formation on the surface of the membrane, or by adsorption of the foulants both on the surface and in the membrane pores. Cake fouling is generally reversible and can be removed by backwashing or water flushing. Foulant adsorption however is irreversible and can only be remedied by very harsh chemical cleaning. Many studies have been conducted to increase the hydrophilic properties of the polysulphone membrane surface. These studies can be divided into three categories: 1) blending PSF with hydrophilic nanoparticles such as SiO_2, ZrO_2 and TiO_2; 2) grafting with hydrophilic polymers, monomers or functional groups; and 3) coating with hydrophilic polymers. Despite these efforts to minimise fouling of PSF membranes during wastewater treatment, there are still many unanswered questions regarding the mechanisms involved. This study will attempt to develop a novel PSF nanocomposite membrane with minimised fouling properties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 000
Expected term: 2010 - 2012

Exploring knowledge on natural processes for novel approaches to constructed wetland design and performance for wastewater using biomimicry
Golder Associates
No. 2096

This study will look to exploit knowledge on natural wetlands, their processes and biodiversity to better engineer/design constructed wetlands to meet the challenges of current and emerging pollutants and pathogens. The study should also look to explore the potential of using constructed wetlands to support sustainable livelihoods. The first phase of this project is innovation-focused and will explore, through the process of biomimicry, novel approaches that can be used to improve constructed wetland design and implementation. The potential exists for this process to deliver innovative solutions for wastewater (both industrial, domestic) treatment, transformation and filtration.

Estimated cost: R3 000 000
Expected term: 2011 - 2016

Programme 2: Application of appropriate technologies and tools

Denitrification in trickling filters
CSIR (Stellenbosch); Virtual Buro;
Tshwane University of Technology
No. 1825

Many wastewater treatment plants in South Africa are equipped with trickling filters which could be obsolete if they cannot achieve denitrification. The researchers aim to demonstrate (at full scale) that trickling filters can denitrify by changing the effluent recycle over trickling filters and/or limiting the rotation speed of distribution arms. They will then model the processes of aerobic COD removal, nitrification and denitrification in a biofilm system and calibrate the model with results from 2 trickling filters in order to gain a better mechanistic understanding of the combined processes. This will result in a set of practical operating guidelines to achieve denitrification in trickling filters.

Estimated cost: R930 500
Expected term: 2008 - 2010

Ultra-sensitive electrochemical nanobiosensors array devices for real-time determination of oestrogenic endocrine disruptors in municipal wastewater (ENDOTEK)
University of the Western Cape
No. 1999

There is a current concern in South Africa that water resources are heavily contaminated with pollutants generally classified as endocrine disruptors or endocrine disrupting chemicals (EDCs). This study will focus on endocrine disruptors that are natural and synthetic estrogenic hormones such as estriol, 17-estradiol and 17-ethinylestradiol and estrone. Estrogenic hormones are the most endocrine-disrupting chemicals because the disrupting potency can be several thousand times higher than other chemicals such as nonylphenol. This implies that natural and synthetic oestrogens can be biologically reactive even at low nanogram per litre levels. Consequently, the detection of these trace contaminants in municipal water resources and their elimination are very important areas of current research interest. The level of contamination of municipal wastewater in South Africa by individual synthetic and natural oestrogens is not fully known and there is no available technology for their real-time determination. The main methods for the determination of estrogenic EDCs have been through vitellogen (a biomarker for EDCs) enzyme-linked immunosorbent assay (ELISA) on fish samples or by chromatographic (HPLC) analysis of wastewater. They are very technical methods requiring extensive sample pre-treatment and high-level qualified personnel. Thus the development of rapid, simple and low-cost procedures for detection of estrogenic activity in wastewater samples is of utmost importance. The proposed research is on the development of a nanostructured electrochemical DNA aptamer array biosensor for detecting and quantifying estrogenic endocrine disruptors in wastewater samples down to the femto- or atto-molar range. The idea is to determine individual oestrogen compounds simultaneously in one measurement using multichannel microchip array signal transduction approach.

Estimated cost: R1 665 000
Expected term: 2010 - 2012

Evaluation of the DEWATS process for decentralised wastewater treatment
University of KwaZulu-Natal
No. 2002

Several WRC projects have looked at the anaerobic baffle reactor (ABR) as a decentralised technology option for wastewater treatment. The DEWATS system aims to provide a treatment train consisting of the ABR connected to a wetland or membranes to study final effluent quality. The aim is to reuse the effluent for agricultural trials and thus link the technology to agriculture and food security. This projected will be piloted in KwaMashu, KZN and aims to: (1) understand the capabilities of the DEWATS system for municipal waterborne sanitation, (2) re-assess the provision of sanitation to poor households and its opportunities, (3) gain experience in using different wastewater streams in agriculture, and (4) gain knowledge in disinfecting treated wastewater using gravity membranes at a larger scale. The data from the performance of the ABR will be compared to that of the earlier laboratory and pilot-scale systems and the previously developed model will be assessed and improved where necessary. The performance of the anaerobic filter compartments will be assessed in a similar way to the ABR compartments. While failure is not expected to occur, the performance under different loading rates will be assessed and a model of this part of the system will be developed. Effluent from different stages of the ABR through the process will be supplied for specific agricultural trials to assess suitability for agriculture. The suitability of the soil at the Permaculture Centre will be assessed for different qualities of irrigation water and a selection of appropriate crops made. Water and nutrient balances will be undertaken across different agricultural plots and the two planted gravel filters to assess the impact of using treated effluent. The removal of pathogens at different points through the system will be assessed and quantitative microbial risk assessments are to be undertaken for agricultural workers and for the use of different crops irrigated in different ways.

Estimated cost: R900 000
Expected term: 2010 - 2012

Microbial database-tool for evaluating the BNR processes in KZN
Durban University of Technology
No. 2003

Biological nutrient removal treatment processes are highly organised systems that depend on a synergy between microbial populations and plant configuration and operating parameters. These microbial populations comprise primarily of functional groups of organisms such as ordinary heterotrophs that facilitate COD removal and denitrification, nitrifiers that facilitate nitrification, phosphate-accumulating organisms that are responsible for biological phosphate removal and filamentous bacteria that are responsible for the formation of the core of the floc in activated sludge processes. There is a fine balance between these different groups that has to be maintained in order for optimal functioning of these processes. Selection of these populations is generally based on influent characteristics, operating parameters and process configuration and therefore the microbial population dynamics in full scale treatment processes are closely linked to the former operational conditions. In South Africa, previous studies on these correlations were conducted a long time ago (Ekama et al., 1999), focusing primarily on engineering paradigms. The microbial population investigations were based on conventional microbiological techniques. With the advent of novel molecular techniques, there has been a paradigm shift in microbial population dynamic studies allowing a high degree of accuracy. An IWA specialist group on activated sludge separation problems stated the general situation in conventional and BNR plants in South Africa (Pitman, 2006), but most of the referenced publications

were over two decades old. Therefore there is need for more updated knowledge in population dynamics. The proposed research will focus on using these novel molecular techniques to accurately profile functional groups of microorganisms and correlate to plant operating parameters and influent characteristics with the aim of understanding microbial contributions. It is hoped that this will aid in optimising plant performance and prevent problems such as bulking and foaming. The approach will be unique in South Africa and findings will be relevant to the South African wastewater treatment systems

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 3: Stormwater and sewerage systems

Investigation into pumps and pressurised flow in separate sewer systems
University of Stellenbosch
No. 2007

In a former WRC study a first-order national audit of sewerage reticulation issues was presented which highlighted amongst others various urgent future research aspects pertaining to sewer infrastructure. The proposal sets out to address a number of pertinent issues with regard to pumps, pump stations, rising mains, and other elements in the sewer system where pressurised flow occurs in separate sewer systems by means of applied research. It is hoped that the research will provide solutions to reducing the high energy input for pump stations. Energy consumption at pumping installations is an ever-increasing concern. From a strategic point of view sewer pump stations form only another component of the entire sewer system. Rising mains are another, and are often separately assessed. However, these two components are integrated hydraulically and should be optimised in combination, not separately. It is hoped this study will link theory to practice when it comes to pumping sewerage. Hydraulics and theory have their place, but a lot of experience has over the years been gained based on practical considerations, particularly as it pertains to local conditions. For example, work on the design and construction of sand/silt/rag traps as well as pump stations by members of the project team has underlined the urgent need to handle insoluble matter of all sorts arriving at sewer pump stations with the flow. This study intends to capture as much of the local knowledge in this field, test and verify it, and present a solution in the form of a tool and guide for use by both academics (e.g. published research to disseminate knowledge among peers; lecture notes) and those in the engineering fraternity (e.g. acting as a design guideline).

Estimated cost: R1 000 000
Expected term: 2010 - 2012

Programme 4: Wastewater sludge and faecal sludge management

Investigation into the long-term risks associated with deep row entrenchment of pit latrine and wastewater treatment sludges for forestry and land rehabilitation purposes
Partners in Development (Pty) Ltd
No. 2097

While South Africa struggles to provide basic sanitation for all, a substantial amount of existing basic sanitation infrastructure (conventional pit latrines and VIPs) has reached or is reaching the end of its design life. Urgent interventions are required to deal with the accumulation of sludge in these units. The low-cost options for the disposal of these sludges are limited. This project aims to establish whether deep row entrenchment of faecal

sludges with agroforestry is a safe, cost-effective and beneficial sludge disposal option. It will add significantly to the understanding of how buried sludge changes in nature over time, in terms of its physical and biological structure. It will also improve understanding of how buried sludge affects groundwater.

Estimated cost: R1 000 000
Expected term: 2011 - 2014

Programme 5: Sanitation technology and innovations

Piloting and testing the pour-flush latrine technology for its applicability in South Africa
Partners in Development
No. 1887

Recent research studies concluded by the WRC have raised many concerns about the long-term sustainability of dry sanitation technologies. The studies have found that the technology has led to unintended consequences due to misuse by users, as well as the lack of understanding of the science of dry sanitation systems. A combination of these factors and the stringent design requirements are proving it difficult to access pits for pit emptying. This is further compounded by user behaviour which is resulting in the intrusion of solid waste, plastics and other undesirables into the pits, resulting in difficulties around pit emptying and the rapid filling of pits. This coupled with the fact that there is no easy mechanical or physical *modus operandi* for servicing full pits. All of these issues are raising many new challenges which jeopardise the sustainability and the target set by government for coverage of sanitation. Amongst the suite of technologies, pour-flush latrines, which are used widely as a basic sanitation norm in South East Asian countries, have the potential to resolve many of these issues. However, very little promotion and application has been done in South Africa. This research study aims to create an understanding of the technical, social and environmental challenges associated with its application.

Estimated cost: R1 000 000
Expected term: 2009 - 2011

An investigation into technical sanitation solutions for informal areas
Cape Peninsula University of Technology
No. 2098

Urbanisation, in fact, is a health hazard for certain vulnerable populations, and this demographic shift threatens to create a humanitarian disaster. The threat comes both in the form of rising rates of endemic disease and a greater potential for epidemics and even pandemics. The poor are especially affected by inadequate and substandard sanitation services and these effects are not only limited to the health impact resulting from daily exposure to polluted habitats. It is recognised that problems caused by informal settlements are multiple. The most difficult is the provision of adequate sanitation services that can sustain livelihoods and protect the general environment from pollution and health risks to humans. Technology is one element in the overall solution to sustainable sanitation for informal areas, but it is an important barrier to the spread of diseases, and also important for the provision of a clean environment. The chaotic settlement patterns and densities, as well as other factors, make many solutions inappropriate and ineffective, and this is further compounded by the lack of institutional support. To date many solutions have been experimented with, with limited success, and we are yet to find the most appropriate solution for informal

areas. This study aims to develop and establish new sanitation solutions for informal areas.

Estimated cost: R500 000
Expected term: 2011 - 2013

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

A tunable immobilised lignocellulosic enzyme (TILE) system for treatment of industrial wastewaters
Cape Peninsula University of Technology
No. 2009

This project will look at biosolubilising lignocellulosics, using a 'Tunable Immobilised Lignocellulosic Enzyme (TILE)' system. This involves rationally selected key enzymes, focusing on integration of their synergistic action to depolymerise lignocellulosic residues. Isolated enzymes are preferred to whole cell organisms because they have greater specificity, are easier to handle and store, and the enzyme concentration used in the process is not dependent on microbial growth. The primary objective is to liberate carbon in a form suitable for uptake as nutrient by biomass, thus removing the carbon and generating clean reclaimable water. This proposal addresses three major global problems: 1) the increasing scarcity of clean water, leading to the need for effective treatment of industrial effluents and reuse of water, 2) agri-industrial effluents which are produced in significant volumes but are problematic to treat cost-effectively, with few successful processes available, and 3) agri-industrial wastes which contain lignocellulosics presenting particular challenges. This work aims to develop a continuous process using immobilised enzymes in a membrane bioreactor incorporating a selected group of enzymes which are immobilised together to effect depolymerisation of the lignocellulosic content of the waste and will include in- situ generation of peroxide and hence prevention of inhibitor build-up.

Estimated cost: R2 200 000
Expected term: 2010 - 2012

Industrial brine minimization: determining the physical chemical parameters that affect evaporation rates on multi-component hypersaline effluents
University of the Western Cape
No. 2100

Brines are a major waste by-product from industrial activities. This study aims to understand and provide solutions for the efficient minimisation of industrial brines. The study will evaluate evaporation rates and design and assemble climate-controlled enclosures for the study of evaporation processes of brines. The data will result in the development of protocols for the measurement of evaporation rates from brines which will lead to the development of empirical models for determining evaporation processes of industrial brines under controlled laboratory conditions and the development of theoretical models for determining evaporation rates of brines. Finally, it is envisaged that this understanding will result in the development of novel textured surfaces and absorbents for enhanced evaporation of industrial brines.

Estimated cost: R1 500 000
Expected term: 2011 - 2014

Evaluation of forward osmosis technology for the treatment of concentrated brines
University of KwaZulu-Natal (Durban)
No. 2101

Forward osmosis is a new technology for industry in South Africa and this scoping project is to assess the applicability for further application of concentrated inorganic brines. The study will aim to evaluate whether forward osmosis can be used as a lower energy consuming technology compared to reverse osmosis. It will evaluate the advantages, limitations and feasibility of using forward osmosis technology to concentrate various high ionic strength wastewaters and to assess the fouling characteristics of forward osmosis on various high ionic strength industrial streams which are known to be badly fouling.

Estimated cost: R354 000
Expected term: 2011 – 2014

Programme 2: Integrated management

Adapting water footprints for South Africa and exploring the value of integrating water, carbon and energy (environmental) footprints for the South African industrial sector
Pegasys Strategy and Development (Pty) Ltd
No. 2099

This study aims to review global and national practices in assessing water, energy and carbon footprints and the trade-offs that industries have to make to meet the goals set. It will investigate tools and methodologies that can be applied to determine water, energy and carbon footprints with the aim to provide a consolidated environmental footprint and a decision support tool. It is hoped that the understanding will be developed through the use of industry case studies.

Estimated cost: R2 000 000
Expected term: 2011 - 2013

Programme 4: Governance, policy, regulatory, and economic instruments to improve industrial water management

Valuing water for South African industries: A production function approach
CSIR
No. 2103

The project aims to ensure more efficient use of water by industry, based on an improved understanding of the marginal value of industrial water, and of the responsiveness of industry to water pricing strategies. This is in keeping with the National Water Act's objective to price water correctly, and will look to feed in to the current DWA pricing strategy.

Estimated cost: R780 000
Expected term: 2011 - 2013

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Adapting constructed wetlands for real-world applications
Cape Peninsula University of Technology
No. 2104

This project builds on previous research and will use the new fingerprinting techniques that have been developed and customised to define the parameters which will allow the effective use of constructed wetlands to treat wastewaters using natural processes. It will also investigate the reproducibility of constructed wetlands adapted for specific waste-containing

waters in varied environments by characterising the microbial communities in these environments, and to understand the extent to which microbial communities in constructed wetlands can accommodate changes in waste impacts and the rates at which they can adapt. Finally it will develop a matrix of parameters and thus guidelines to use to adapt wetlands.

Estimated cost: R1 100 000
Expected term: 2011 - 2015

Integrated photo-catalytic and anaerobic treatment of industrial wastewater for biogas production
Vaal University of Technology
No. 2105

This project aims to test, at a laboratory scale, the use of zeolite as a support material to improve biogas production and anaerobic reactor stability. In addition, the study will concentrate on synthetic industrial effluents and use a photocatalyst (titanium dioxide) to break down these complex chemicals to simpler ones and evaluate the anaerobic reactor efficiency. Knowledge from these tests can be used in future to improve anaerobic digestion efficiencies by allowing microorganisms to come into contact with simpler compounds and prevent washout of the sensitive methanogenic bacteria.

Estimated cost: R500 000
Expected term: 2011 - 2013

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Toxicity evaluation of metals and metal oxides nanoparticles to aquatic invertebrates and algal species
CSIR
No. 2107

Since the beginning of the 1990s, nanotechnology has matured from a laboratory-based research and development phase into full commercialisation of nanoproducts. For example, there are numerous novel consumer products and industrial applications of nanotechnology including: nanoelectronics, molecular assemblies, tissue engineering, biomedicine, nanocomposites, cosmetics, paints, pesticides and water purification modules. Among the nanomaterials, used in the nanoproducts reported above, with high potential of release in large quantities into aquatic environments are metals and metal oxides. In view of the rapidly increasing quantities of nanomaterials released into different environmental compartments – especially water and sediments – it is imperative that the potential risks that may be associated with nanomaterials attract attention, to ensure long-term safe, responsible, and sustainable development of this novel technology for optimal benefit of society. Due to the limited data, on potential risks of nanomaterials to aquatic organisms, which could support practical risk assessment and risk management after entry into the environment, this project will investigate the effects of nanomaterials on organisms at different trophic levels. Secondly, the mechanism by which nanomaterials cause toxic effects to the receptor organisms will be explored through use of DNA, reactive oxygen species (ROS) generation techniques.

Estimated cost: R495 000
Expected term: 2011 - 2014

Programme 3: Minimising waste production

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation
University of Cape Town
No. 2108

The main aim of this research is to further the understanding of the precipitation of metal sulphides in the treatment of acid mine drainage via sulphate reduction and metal precipitation. The project will characterise the effect of operating conditions on the physical characteristics of the formed metal sulphide precipitate by investigating the effect of metal to sulphide ratio on precipitation behaviour, the effect of the operating pH on the precipitation process and using a technique based on moment transformations of the number density function n(L) to make inferences about the mechanisms involved in the particle formation processes. The project will also investigate the factors affecting the solid-liquid separation characteristics of the formed particles. The effects of the processing conditions on solid-liquid separation characteristics of the formed precipitates will be quantified using particle size distribution measurements, settling characteristics and zeta potential measurements for surface charge determination. These studies will be carried out on a number of model metal systems. Finally, the project will investigate factors that potentially influence the solid-liquid separation characteristics of the formed particles. As a result of the investigations carried out, it should be possible to identify a number of factors, possibly different additives, which would influence the separation characteristics of the formed precipitates. Thus the effect of these ions (as well as other additives) on the coagulation and aggregation phenomenon will be quantified by measuring their effect on particle size distribution, surface charge and settling characteristics of the precipitate.

Estimated cost: R884 820
Expected term: 2011 - 2013

Development of a toolkit to enable quantitative microbial ecology studies of sulphate-reducing and sulphide-oxidising systems
University of Cape Town
No. 2109

The catastrophic effects of untreated mine-water discharges are well known and several high profile events have been documented. Mine-water has traditionally been treated using oxidation-neutralisation-precipitation which effectively removes metal, but the treated stream still contains sulphate. Biological treatment systems, based on the activity of sulphate-reducing bacteria have received considerable attention. Their widespread application has been constrained by the provision of a carbon source/electron donor and the management of the sulphide-containing effluent. Both these issues are addressed in the Integrated Passive Treatment System (IMPI) technology which makes use of a mixture of complex, lignocellulosic carbon sources and incorporates a sulphide oxidation step. Both the sulphide oxidation and sulphate reduction processes are catalysed by a consortium of different microorganisms. Different components of the consortium have different tolerances to sulphate, sulphide and heavy metals. As a consequence, changes in feedstock can lead to major changes in the microbial community. This may have catastrophic effects on system performance. Until recently these changes were poorly understood and system management was based on empirical rules of

thumb. The advent of molecular biology techniques has facilitated qualitative microbial ecology studies. While these have been useful in confirming the presence or absence of species or groups of species they provide limited information on dynamic changes in population structure, which could be extremely useful in predicting the response of a system to specific perturbations. This project will develop a molecular toolkit for performing quantitative microbial ecology work in sulphate-reducing and sulphide-oxidising systems. The toolkit will initially be used to characterise the microbial populations in the IMPI demonstration plant at Middleburg Mine. This technology has the potential to treat mine-water effectively and economically over a sustained period of time.

Estimated cost: R487 500
Expected term: 2011 - 2013

Addressing the challenges facing biological sulphate reduction as a strategy for AMD treatment through analysis of the reactor stage: raw materials, products and process kinetics
University of Cape Town
No. 2110

Mine-waters generated during active mining or resulting from groundwater rebound at abandoned sites have major environmental and economic implications. Active chemical treatment of the waters is the most widely employed technology. Recently there has been increasing interest in active and passive biological treatment processes. These systems rely on naturally-occurring biological and geochemical processes to improve water quality with minimal operational and maintenance requirements. Biological sulphate reduction is a well understood and efficient process that has been frequently demonstrated at laboratory and pilot scale. However, its full-scale implementation has been limited. The challenges facing sulphate reduction systems have been identified as: provision of a cost-effective carbon source; enhancing reaction kinetics when complex carbon sources are used; and management of the resulting sulphide. This study will undertake a critical review of existing technologies, from a technological and economic perspective. Furthermore the feasibility of using microalgal biomass as a carbon source/electron donor will be investigated. The study will also evaluate the requirements for algal cultivation at the scale required to sustain the SRB process. To address the issue of enhanced reaction kinetics the effect of decoupling the hydrolysis and acidogenesis reactions from the sulphate reduction will be investigated. The study will include a review of available technologies and investigate the application of cross-flow microfiltration membranes to recover and recycle biomass to both the hydrolysis/acidogensis and sulphate reduction reactors.

Estimated cost: R1 050 000
Expected term: 2011 - 2014

Programme 5: Low-volume mined products

Application of emulsion liquid membranes in the recovery of platinum group metals from precious metal refinery wastewaters and mining effluents
Rhodes University
No. 2011

Growing attention has been paid to the environmental implications of liquid effluents from mines and metal refineries. At the same time, water demand of the mining/metal refinery operations and values of precious metals have been increasing while the known reserves have decreased. This led to intense research into the recovery of precious metals from wastewaters. Methods studied include solvent extraction, biosorption,

precipitation, ion exchange, electrochemical techniques, cementation, and membrane-based separations. Applicability of a particular method will depend on the speciation and the concentration of the metal in question, as well as on the chemical composition of the effluent in question. These factors can limit the efficacy of individual processes. Solvent extraction with emulsion liquid membranes (ELMs) reduces energy and financial costs, the kinetics of extraction is generally faster, and the extraction yields are higher in comparison with diluent-extractant mixtures. The disadvantages of ELMs include the instability of emulsion globules against shear fluid stress, and the resulting decreases in the rates of mass transfer. These drawbacks can be eliminated by increasing the stability of the ELM through the application of non-Newtonian ELMs, and the application of the Taylor-vortex column instead of the continuously stirred tank. After the design of an efficient extraction system at laboratory scale, the scale-up can be achieved by a simple constancy of the Taylor number, thus reducing the process development costs. The application of this process to precious and platinum group metals (PGMs) has not been investigated. The aim of this project is to fill this knowledge gap, and to examine the chemical changes and toxicological implications of the proposed process.

Estimated cost: R337 450
Expected term: 2010 - 2012

NEW PROJECTS

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost recovery in water services

Identifying efficiency and inefficiency in municipal water service provision
Nelson Mandela Metropolitan University
No. 2118

A very important, but perhaps neglected type of efficiency analysis of water service provision is that of the efficiency in mix of water service output. It has the aim of getting the right product mix. An analysis of efficiency in the mix of water service output relates the service produced to demand. It is not efficient to produce a mix of outputs that the recipients cannot afford. Nor is it efficient to produce less output than the recipients are willing to pay for. There are many very important issues related to this type of efficiency assessment. The main methodological aspect which this proposal concerns itself with is efficiency in the production of water service outputs – cost efficiency, including the choice of least-cost production technology. The aim of doing so is to enable regulation by an independent body of this aspect of municipal water service provision.

Estimated cost: R970 000
Expected term: 2012 - 2015

Programme 2: Institutional and management issues – Water services

Constraints on providing sewerage in South African informal settlements: A study of social and institutional management concerns
University of Cape Town
No. 2120

Full-flush toilets are generally preferred by residents and deemed by the National Government as being the most appropriate technology for dense urban settlements. Yet standard conventional (gravity) systems are costly to implement and sometimes impractical in flat terrains where residents, fearing increased marginalisation, have resisted relocation. Further challenges arise because informal settlements are often regarded by planners as temporary, with the result that sanitation services installed are not always of high quality. Municipal officials countrywide report a pattern of shared (communal) facilities in densely-populated informal areas deteriorating rapidly, allegedly a result of mismanagement and apparently senseless destruction. All of these situations are likely a consequence of residents' desire, and increasingly their demand, for security of tenure and a national policy for service delivery that is supply-side driven. While present policy is indeed supply-side driven, it makes no provision for sanitation management costs despite this being an expectation of residents who claim a right to free operation and maintenance of communal sanitation services (O&M). This study intends to analyse the social and municipal concerns with, and attempts to address, current sanitation planning and management processes. Many municipal officials question how to achieve this economically and rapidly, and on a large enough scale that it results in services which residents are satisfied with and will develop a sense of propriety over and therefore protect. The research hopes to assist municipal officials, and, by extension, residents, by first detailing the criteria whereby and reasons that officials and residents consider some sanitation projects 'successes' and others 'failures'.

Estimated cost: R1 000 000
Expected term: 2012 - 2014

Social protest and water service delivery in South Africa
University of the Western Cape
No. 2133

From a planning perspective, lack of simple correlations in the occurrence of water services related protests raises an important methodological question about whether or not such unrest can be predicted and/or pre-empted. Although useful quantitative and qualitative insights on social protests are provided by Municipal IQ and by the Dialogue Unit of the Institute for Democracy in South Africa (IDASA), a major problem is that much of the evidence on social protests is based on media reports and anecdotal evidence, with a limited range of in-depth scientific analyses. Post-apartheid reforms have not only partially resolved these inequalities, but have also spawned unprecedented social challenges associated with societies in transition. For example, formal institutional responses to the mushrooming of urban informal settlements have often failed to keep pace with urban social change and many such settlements remain with insecure access to water. Similarly, formal institutional responses in rural areas have often fallen short of meeting newer social consumption patterns, livelihood aspirations and expectations for service delivery. A key question for further research is why water-related protests have largely been confined to urban areas, irrespective of socio-economic status. The study will provide for an in-

depth scientific understanding of this development and a broadened focus to include both the lived realities of historically disadvantaged individuals (HDIs) in informal rural and urban economies as well as those of other socio-economic groups within South Africa.

Estimated cost: R1 500 000
Expected term: 2012 - 2015

Programme 3: Innovative management arrangements – Rural water supply

Capacity building for climate change adaptation and disaster risk reduction in rural South African Communities: Tsengiwe, Eastern Cape
Umvoto Africa
No. 2126

The study follows on recommendations made in WRC K5/1888//3 (Investigating the Social Vulnerability of People and their Livelihoods and their Response to Water Infrastructure) to refine the proposed methodology for risk assessment. Improving understanding of community-level risk was partly achieved by adapting the HFA (which provides a framework for risk reduction at the national level) to develop community level indicators for social vulnerability and coping capacity. Several recommendations for improving risk assessment at the community level arose from the WRC study, in particular, the inclusion of community-based climate change planning and adaptation.

Estimated cost: R800 000
Expected term: 2012 - 2015

Sanitation subsidies in perspective: how to increase the effectiveness of sanitation subsidies in South Africa
Sustento Development Services
No. 2136

There is a growing perception amongst sanitation practitioners in South Africa that the increase in the capital cost for construction of a basic sanitation facility has escalated beyond inflation-related increases in the past 10 years. The perception is that the cost of providing a subsidised flush or VIP toilet is currently significantly and unreasonably higher than what is was 10 years ago. However, it is unclear whether this perception is correct, and, if so, what the drivers are of these escalating costs. With regulation of provision of basic sanitation being assigned to the new Department of Human Settlements, the department responsible for administering the housing subsidy, there is a lack of clarity as to how the MIG sanitation subsidy processes and procedures integrate or conflict with the low-cost housing subsidy processes. There are perceptions in the sector that some households have benefited from both subsidies and thus there are cases where households received two subsidised toilets through the MIG and through the housing grants. The study will investigate the historic and present economic and social cost of subsidised sanitation facilities constructed from MIG and housing grants and determine the overlaps between, and gaps in, sanitation-related subsidy policies and processes.

Estimated cost: R488 765
Expected term: 2012 - 2014

Programme 4: Regulation in the water services sector

Municipal guidelines for implementing WDM
WRP Consulting Engineers (PTY) LTD
No. 2130

Water demand management (WDM) is becoming a key issue throughout South Africa. Many books and publications have been produced to assist water supply managers to develop strategies to address the various WDM issues and many software packages have also been developed to assist in this regard. The emphasis is now moving from the development of WDM strategies to the actual implementation of WDM interventions. The proposed guidelines are therefore aimed at providing useful information and advice on a wide variety of WDM interventions as they should be applied in a South African context. When completed, the guide will provide a useful reference to all water supply managers in South Africa who are intending to implement WDM interventions in their supply areas. The guidelines will concentrate on the practical implementation of WDM measures rather than the theory or background to such measures.

Estimated cost: R500 000
Expected term: 2012 - 2014

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Investigation into the cost and water quality aspects of South African desalination and reuse plants
SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2121

Desalination and wastewater reuse by various membrane processes ranging from micro-, ultra-, and nanofiltration to reverse osmosis, in combination with other advanced technologies, can be used in different configurations to augment water supplies. With known feed-water and target product-water qualities the basic plants are relatively standard and consistent in price. However, the infrastructures in front of (intakes, pre-treatment, etc.) and following (waste discharge, product water pumping systems) the basic plant building block (membrane system) are major variables in determining the capital and operating costs of the selected solutions. Each location and situation has different advantages and challenges to be evaluated in making the best decisions for implementation. This project will compare and document actual cost and water quality data from various South African projects to establish a first-order knowledge base for desalination and reuse for the augmentation of water supply in a South African context.

Estimated cost: R1 000 000
Expected term: 2012 - 2015

Advanced oxidative treatment process for water disinfection using an electrohydraulic discharge reactor and TiO_2 immobilised on nanofibres
University of the Western Cape
No. 2132

In this project, the design and methods for applying electrical energy to multiple electrodes will be explored and described. An assembly having at least more than two electrodes may be configured such that the high voltage electrodes are submerged in the inner tubes, positioned at parallel relative to one another, and the grounded electrode is directly submerged into the wastewater setup, resulting in production of a cocktail of chemical species, such as OH radicals, ozone and hydrogen peroxide, which can target and

attack the pollutants in the water without the addition of chemicals. Electrohydraulic discharges have been studied for several years; however, the integration of innovations in nano-science and nano-photocatalytis has been incorporated into this area of research on a very limited scale. The new system will be designed so as to generate plasma directly in water, which will produce radicals from water ionisation. Furthermore, in this multifunctional reactor multiple electrodes across the water flow path, in combination with TiO_2 electrospun nano-fibre consolidated photocatalysts, are applied that can promote and enhance the formation of oxidants.

Estimated cost: R1 392 800
Expected term: 2012 - 2015

Decision-support model for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery (with focus on upgrading options, water reclamation and desalination)
Chris Swartz Water Utilisation Engineers
No. 2119

Water supply authorities (WSAs) in South Africa are currently facing two major challenges with sustainable supply of sufficient quantities of high quality drinking water to the population. On the one hand is the highly variable availability of raw water sources due to changing weather patterns (resulting in prolonged drought periods (spatially and temporally) and intermittent flooding periods), while at the same time poorly-capacitated municipalities are experiencing major problems with water service delivery. Various options are available when WSAs, the Department of Water Affairs (DWA), planners and funders (such as DBSA) want to improve the water source surety (and sustainability) or make provision for drought periods. Sufficient information on the options is most often not readily available for the planners/authorities to make informed selection of the best options for a specific situation. The information that is lacking includes technical, costing, energy and environmental data. Even if the data and information are obtained, comparison of the best possible options is not feasible or effective, because of the differences in priorities assigned to the multitude of factors making up the main components of the selection criteria. This project will therefore create a decision-support system that can be used by municipalities and water boards to identify, evaluate, compare and select appropriate options that can be used to produce sufficient quantities of safe drinking water from available water sources.

Estimated cost: R450 000
Expected term: 2012 - 2014

Programme 2: Water treatment technology for rural communities

Point-of-use disinfections systems designed for domestic rainwater harvesting (DRWH) tanks for improved water quality in rural communities
University of Stellenbosch
No. 2124

Domestic rainwater harvesting (DRWH) has the potential to improve water availability in rural communities in Southern Africa. In the Eastern Cape and KwaZulu-Natal DRWH is already an important source of drinking water. The quality of water collected by DRWH remains disputed with reports of microbial contamination above acceptable drinking water standards. Water collected by RWH therefore needs to be further treated in many cases to adhere to drinking water standards. Chlorine, slow sand filtration and pasteurization by solar technology have been proposed for treating rainwater

in tanks. The objectives of this study are to determine the microbiological and chemical quality of rainwater collected in existing DRWH tanks; and to install tanks at a university for investigation of cost-effectiveness, material analysis and filter systems. Lastly the social perception and feasibility of the tanks in the community will be explored.

Estimated cost: R746 000
Expected term: 2012 - 2014

Programme 3: Drinking water quality

An investigation into the presence and impact of free-living amoebae and amoeba-resistant bacteria on drinking water production, storage and distribution to health care institutions in greater Johannesburg, South Africa
National Institute of Occupational Health
No. 2138

Free-living amoebae (FLA) are ubiquitous in groundwater and surface waters used for drinking water production. They feed on smaller micro-organisms like bacteria, fungi and algae. Although mostly non-pathogenic, some FLA, particularly *Acanthamoeba* and *Balamuthia* species and *Naegleria fowlerii* are known human pathogens which may cause life-threatening disease in both healthy and immunocompromised individuals. They can survive in this dormant stage for long periods of time, only to excyst and become active again when conditions return to normal. International studies continue to highlight the potential of FLA containing amoeba-resistant bacteria (ARB) to survive routine drinking water production and treatment processes. The overall aim of the study is to establish whether the occurrence of FLA and ARB in drinking water production plants has an impact on the quality of the water supplied to health care institutions in greater Johannesburg, to use this information to assist the drinking water production industry to improve the quality of water supplied to these institutions and to assist the institutions to establish appropriate water management programmes in areas where the patients and personnel are most at risk of infection.

Estimated cost: R423 500
Expected term: 2012 - 2015

Programme 4: Water distribution and distribution systems

Practical guidelines for operation and maintenance of water distribution systems in South Africa
University of Cape Town
No. 2135

Proper operation and maintenance procedures are key to ensuring that the investments in new infrastructure provide a continuous and sustainable high level of service. Components of water distribution systems do not last forever, and need to be operated within their design parameters and inspected, repaired and replaced at appropriate times to ensure that the integrity of the infrastructure is maintained. Lack of proper operation and maintenance invariably leads to faster degradation of the infrastructure, with an associated decrease in service levels of both quantity and quality of water supplied. If this process is not checked, it eventually leads to complete breakdown of the system integrity, which requires the infrastructure to be replaced at huge cost. This project will provide clear and practical guidance on the operation and maintenance of water distribution systems. The focus of the project will be on applying current knowledge on water distribution management to South African conditions, and to make this information accessible to South African engineers and managers.

Estimated cost: R757 000
Expected term: 2012 - 2013

Determination of the change in hydraulic capacity in pipelines
University of Pretoria
No. 2140

Optimal capital expenditure and operational cost is based on the performance and the expected hydraulic performance decay rate of pipeline systems. Long-term performance data is essential for this assessment and an effort should now be made to gather information on a regular basis for a number of different pipelines in South Africa. This research, which builds on previously-completed work, will broaden the database, maintain the current momentum of the original research and will provide improved understanding of the hydraulic behaviour of pipelines to be able to improve the design philosophy. The preliminary finding was that the presence of biofilm significantly reduces the hydraulic capacity. In this study emphasis will be placed on the review of newly-installed pipelines (sewage, raw and clear water), but existing pipelines will also be included in the field work. A roughness database reflecting the hydraulic capacity time history will provide a sound basis for the design of new pipelines as well as assist in the operation and refurbishment of existing pipelines.

Estimated cost: R1 125 000
Expected term: 2012 - 2015

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER MANAGEMENT AND SANITATION

Programme 1: Emerging technologies and solutions

Characterization of indigenous anaerobic ammonium oxidizing (anammox) bacteria grown in microaerobic environments
University of Pretoria
No. 2117

The project builds on the lessons learned in an earlier WRC-funded project conducted by Stellenbosch University entitled 'Fishing for indigenous anammox bacteria'. The main goal of the study was to find out if anammox bacteria exist in some South African anaerobic environments. The study has shown some impressive results with regards to the existence of these bacteria from various habitats. However, the researchers had difficulty in obtaining sufficient biomass to sustain the anammox process using the gas-lift reactors. In addition, the study also showed that oxygen is very inhibitory to the growth of anammox. Furthermore the constant feeding and mixing of the reactor contents resulted in biomass washout thereby hampering the progress of the enrichment process. Based on the abovementioned findings, the principal objective of this proposed study will be to develop an anammox enrichment system that will be designed to endure microaerobic conditions

Estimated cost: R460 400
Expected term: 2012 - 2014

Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems
CSIR
No. 2122

In contributing towards our collective understanding on the fate, behaviour and transportation of engineered nanomaterials, ENMs, in WWTP processes. This study will be to establish possible mechanisms of ENM accumulation and/or degradation in wastewater sludge, as well as the potential effects of ENMs on the microbial population which could be useful in current wastewater treatment processes. To understand the fate, behaviour and transportation of ENMs in the environment, the following processes, viz: aggregation, adsorption, complexation, entrapment, degradation, reactivity, mobility or degree of stability, given the size of ENMs which is within the colloidal region, will be carefully investigated. The derived knowledge will provide sound evidence to allow for the search for technologies that can remove ENMs from wastewater efficiently.

Estimated cost: R680 000
Expected term: 2012 - 2014

Performance and efficacy of integrated algae ponding systems in wastewater treatment for water reuse and cost recovery through biomass valorization

Rhodes University
No. 2123

A rapid implementation of robust, easy to deploy and operate, sustainable wastewater treatment technology is urgently required. Furthermore, climate change, together with reduced water availability, has major food security implications for South Africa, its neighbours, and other arid, water-poor countries. These two factors alone have profound management implications for both government and business. Correct implementation and management of integrated algae pond systems (IAPS) developed for South African conditions can produce clean water for recycling and reuse, provide energy, and generate a biomass suitable as a broadcast or liquid fertilizer in organic row crop agriculture and high-value horticulture. Even so, and as with any near market-ready technology, there is an element of risk and/or failure to comply. Performance of the IAPS needs to be closely monitored and its efficacy in routinely producing a final effluent that meets the standard (i.e. <75 mg/L COD and <25 mg/L SS) thoroughly elaborated. Futhermore, an evaluation of all factors contributing to final COD and SS must be carried out and included: design and re-design of the algae settling tanks, introduction of more robust separation/filtration technologies for removal of biomass and/or water, and full characterisation of the residual COD and SS in the final effluent. Armed with this information a document emphasising the merits of IAPS and addressing questions and concerns about its implementation will be available to facilitate informed decision making.

Estimated cost: R1 500 000
Expected term: 2012 - 2015

Integration of aquatic chemistry with bio-process models

University of KwaZulu-Natal
No. 2125

The IWA has has set up a task group to develop a 'physico-chemical framework' for modelling of water and wastewater treatment processes. The inaugural meeting of the task group took place at the Watermatex 2011 conference in San Sebastian, 20–22 June 2011. Two South African researchers are members of this task group, because models which they have developed over a series of WRC projects already exhibit many of the characteristics which are consistent with the aims of the group. A substantial part of the proposed project will involve transferring the technology represented by

models which have already been developed, and which incorporate the principles set out in the IWA task group motivation. However, in keeping with the systematic approach of the task group, the underlying theory needs to be set out in a comprehensive reference document, together with training material for use in post-graduate courses. Furthermore, the application of the models needs to be demonstrated in practical case studies.

Estimated cost: R480 000
Expected term: 2012 - 2013

Development and demonstration of a woven fabric immersed membrane bioreactor package plant for decentralised sanitation
University of Stellenbosch
No. 2287

South Africa faces a challenge in providing sanitation for all of its people. Decentralised, small-scale 'package' sanitation plants have great potential to overcome some of the logistical challenges and could make a significant contribution to the roll-out of sanitation in peri-urban and rural areas. Internationally, there has been a major swing towards immersed membrane bioreactor (IMBR) technology for wastewater treatment due to the advantages that IMBRs offer over conventional biological wastewater treatment. IMBR package sanitation plants could have a significant impact on addressing the sanitation backlog. However a major barrier to the application of IMBRs is the cost and lack of robustness of current IMBR membranes. Generally, current commercial IMBR membranes are expensive and cannot withstand rough handling. Further, there is a perception that IMBR technology is 'first-world', complicated, and requires highly skilled operators, and hence cannot be applied for decentralized sanitation in developing regions. To enable South Africa to benefit from IMBR technology this project will demonstrate to wastewater practitioners, vendors of package plants, etc., that IMBR technology can be simple, robust, easy to operate and cost effective.

Estimated cost: R793 875
Expected term: 2013 - 2015

Programme 2: Application of appropriate technologies and tools

Self-regulation of the package plants/small wastewater treatment industry: Development of a framework of standards, a conceptual model for a test facility and an accreditation system for each technology provided by suppliers
Royal Haskoning DHV
No. 2193

The SWWTW industry in South Africa has grown rapidly from a small base and is currently unregulated in terms of process design, construction materials, etc. Most of the suppliers are not process experts but rather entrepreneurs who have funded the development of their product using limited resources. Furthermore, SWWTW's are often purchased on the basis of purchase cost which means that at present product costs have to be minimized. This is achieved by omitting any form of redundancy in the plant such as aerators and pumps, overloading media, and using optimistic upflow rates in settlers. Lack of regulation of the SWWTW sector has led to a number of problems in terms of performance, durability and reliability. This project aims to use the experience gained locally, together with international standards and practices to develop:

- A framework of appropriate standards for the SWWTW industry

- Implementation of the standards in a simple manner without duplication
- A conceptual model with key criteria for an independent testing facility for the different technologies
- An accreditation system for the various technologies which will encompass technical and managerial aspects. This would be based along the lines of the Green Drop system, but taking into consideration the fragmented roles of the sector stakeholders. The study will also evaluate who should manage and audit the accreditation process, the cost of the process and who bears the cost.

Estimated cost: R800 000
Expected term: 2012 - 2014

A gap analysis of technologies, techniques and capacity for the water and wastewater (domestic and industrial) sector in South Africa
University of Cape Town
No. 2258

The rationale for the study is to address the concern that multiple research nodes in water-based research in South Africa are largely organic in nature, without significant design, and are not necessarily aligned with national initiatives such as the National Planning Commission, the National Strategy for Sustainable Development and Action Plan, and the 10-Year Innovation Plan of the Department of Science and Technology. The principle aim of the study is to provide an overview and analysis of the gaps involved in water and wastewater research including development, demonstration and commercialisation of products and technologies. The study will also critically evaluate the technology needs of the sector and provide recommendations on how best to synergize areas of expertise in water and wastewater research along the value chain, linking applied research to technology or product development, with the final outcomes being a more robust product development, efficient technology transfer and the building of capacity and competence in the sector to service the technology, products and services. The study will contribute to new insights in the social, environmental and economic fields of knowledge to support the national effort to identify and safeguard human resource capacity, technologies and techniques in the water sector. The response to the gap analysis study must demonstrate a clear understanding about what needs to be done to assure the sustainable supply of water and wastewater treatment in continuing to meet the social and environmental needs of South Africa.

Estimated cost: R450 000
Expected term: 2012 - 2013

Programme 4: Wastewater sludge and faecal sludge management

Quantifying the fertilizer value of wastewater sludges for agriculture
University of Pretoria
No. 2131

This study follows on from a previous WRC project (K5/1724/3) on the sustainable agricultural use of sludge. The previous project included a local field-scale study, conducted across a range of cropping systems using anaerobically-digested air-dried sludge and incubation trials for model N and P parameterization. This study highlighted that sludge application rates that attempt to match nutrient supply to crop demand depend on cropping intensity, availability of water,

management practices, and sludge N and P content. In order to accommodate such complex interactions between sludges, soils, climate, and cropping systems, a mechanistic nutrient (N and P) balance cropping-systems model (SWBSci) was developed for use as a reasoning support tool to guide decision makers with the responsible use of municipal sludges in agriculture. The model was calibrated and validated under various cropping systems, proving its potential as such a reasoning support tool. This model is a fairly complex scientific research tool, and requires detailed weather, soil, crop, and sludge parameters in order to be deployed. Interest in using the model to assist with the development of sludge management strategies for different wastewater care works has been expressed on several occasions by industry partners. However, in its current form, routine use of this reasoning support tool by industry partners or extension officers is highly unlikely, as parameterization is not completely trivial, and there is a definite need to simplify the procedure to follow in running simulations. In order to render this tool more usable, the model needs to be populated with soils, crops, and long-term weather data parameters around the perimeter of wastewater care works, as well as sludge parameters. Sludge parameterization for the various N and P pools relies on a long-term incubation trial which is tedious, time consuming and impractical in real life. Therefore, practical and affordable methods are required to identify the various N and P pools for model parameterization. It is also vital to add a simple heavy metal module into the model to estimate the accumulation of heavy metals in the soil profile across time. The long-term trial could be continued for another three years to validate and calibrate the heavy metal model. This is because beneficial agricultural use of sludge is prohibited if the concentration of heavy metals in the soil profile exceeds a certain threshold value. The model can then be run for various scenarios for several local cropping systems to generate a database of options.

Estimated cost: R2 100 000
Expected term: 2012 - 2015

Programme 5: Sanitation technology and innovations

Investigation into risks of exposure of workers and households to pathogens through current desludging practices and development of guidelines to minimise risks
Partners in Development
No. 2134

There is strong growing evidence that the methods used to empty the pits of on-site sanitation systems result in transmission of disease from sludge to workers or householders This undermines the impact of basic sanitation and health objectives of breaking the cycle of faecal-oral disease transmission. This study aims to investigate the risks of transmission of pathogens to workers or householders through current emptying methods and to develop guidelines for institutional support to minimise these risks.

Estimated cost: R1 200 000
Expected term: 2012 - 2015

Pour-flush and Portapotty sanitation systems
University of KwaZulu-Natal (Durban)
No. 2137

The nature of the waste material from a pour-flush system is different to that of a pit latrine (in that it has a higher moisture content and contains all the urine) and that of a septic tank (in that it is much more concentrated and does not contain any grey-water).It is believed that

moisture content and ammonia concentration affect the rate of biological degradation of any waste stream, but these effects have not been clearly established for pit toilet, pour-flush toilet and septic tank contents. This study will investigate the nature of the feed (specific loading and composition), the extent and kinetics of biodegradation, which need to be determined in order that a rational design procedure can be proposed.

Estimated cost: R1 281 500
Expected term: 2012 - 2015

Demonstration and scaled-up implementation of pour-flush sanitation in South Africa
Partners in Development
No. 2203

While many South Africans aspire to full waterborne sanitation, this is not an achievable goal given the many demands on limited resources. The alternative has been limited to VIP's. However, these are not without their shortcomings including health and safety, environmental and operational issues. In 2009 the WRC commissioned a project to develop and test a prototype for pour-flush sanitation in South Africa. This was done successfully and 20 units have now been in operation for between 7 and 22 months. Funding was received from Irish Aid to demonstrate, on the strength of lessons learned, a large scale pour-flush sanitation pilot and to share the experiences from this pilot with appropriate audiences. Thus the objective of this study is to implement 275 pour-flush units in a rural community.

Estimated cost: R1 475 175
Expected term: 2012 - 2013

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1 : Emerging challenges and solutions for the 21st century

Application of mineral carbonation processes for brine remediation
University of the Western Cape
No. 2128

Currently the typical method of brine disposal is the use of evaporation ponds, which is aimed at reducing the volume of the brine and providing a manageable solid product. Unfortunately, this approach does not stabilize the brine and the cost of long-term storage is still very expensive. Fly ash is another waste material that is being produced in huge amounts by coal-fired power plants. Eskom for instance produces 36.7 Mt of fly ash per annum. The majority of this ash is disposed of in ash dumps while only 5% is applied in the making of building and construction materials. This fly ash presents a major resource that can be utilized in the carbonation of brine, thereby leading to the formation of carbonates which are benign and can be applied as mine backfill. This project proposes to utilize fly ash through mineral carbonation to remediate the effluent brine, which would lead to potable water that can be reused in the power generation process as well as domestic and agricultural purposes. Moreover, this will also lead to reduction of the carbon emissions from power plants.

Estimated cost: R1 362 750
Expected term: 2012 - 2015

Programme 3: Quantification, prediction and minimisation of water use and waste production

Water management efficiency: The development and testing of an optimisation model at selected Eskom sites for an integrated water solution
University of Pretoria
No. 2289

Pinch analysis is a process integration tool, which was first developed for the design of heat recovery systems during the late 1970s. This work formed the basis for the design of water-using systems, with a design objective of minimising water consumption by maximising the reuse of water, using a graphical technique which was termed Water Pinch Analysis. Water Pinch Analysis thus involves a set of systematic formal techniques to handle the complex problem of hierarchical water allocation to a system consisting of a number of processes, and choosing the best combination of strategies. The WRC has funded several projects (1241/1/06; 1158/1/05; 851/1/01) in the past to test the applicability of the technique for water management in both the industrial and water resource fields. The industry-based studies investigated the applicability for three large water users to varying degrees of success and were valuable in gaining insights into its application, limitations and theory. Water Pinch Analysis exposed the water sector to a new technique and developed new capacity in the research domain. These studies also showed that pinch analysis could be used as a neutral tool to set targets and to indicate their environmental performance to the public and authorities. Thus, this study aims to build on the knowledge gained and to develop, test and apply an optimization model for cooling water systems at selected Eskom sites. This project also aims to build capacity for optimization models for water management efficiency.

Estimated cost: R1 500 000
Expected term: 2013 - 2016

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 2: Regulatory, management and institutional arrangements

Development of risk criteria for water management aspects of mine closure
Golder Associates Africa
No. 2127

The DWA recently produced a series of Best Practice Guidelines that give specific guidance on procedures to be adopted in the development of mine closure plans (BPG G5) and in the prediction of future impacts that are associated with mine closure (BPG G4). While the BPGs provide clear methodologies for undertaking the assessments required to support a mine closure application, they do not provide any practical guidance on how issues such as: agreement on the acceptable levels of confidence for the prediction that will limit the State's liability to acceptable levels; statistical representivity of the datasets used in the prediction and their suitability for addressing the issues that pertain to the particular closure application; the definition and descriptions of uncertainty inherent in the predictions and acceptance that the defined uncertainty meets the requirements of the regulator; and the suitability and adequacy of financial provisions to cater for uncertainties and risks for post-closure water management and treatment. This project will address the above issues through review of international best practice on these topics and engagement with all stakeholders (DWA, DEA, DMR, mining industry and consultants) in order to provide guidance on how

to address these issues when considering impact predictions and mine closure applications.

Estimated cost: R535 000
Expected term: 2012 - 2014

Programme 3: Minimising waste production

Treatment of mine water using a combination of coal fly ash and flocculants in a jetloop reactor system
University of the Western Cape
No. 2129

The generation of contaminated high-sulphate mine-water and waste coal fly ash are undesired by-products in coal mining and coal-fired power stations, respectively. Mine-water is contaminated by contact with oxygen and pyrite-bearing rock, or leaches from mine tailings due to infiltrating rain. Mine-water produced in coal mines could be acidic, neutral or alkaline depending on the geology of the mines. Acidic mine-water, often termed acid mine drainage (AMD) is produced when rock that contains more acid-producing minerals than acid-neutralizing minerals was disturbed during mining. Prior work has been done on the fly ash neutralization process and stability of solid residues formed during neutralization, as is recorded under the 'general information' section. This study will optimize the jetloop reactor system which will make this system using fly ash for remediation viable in an industrial environment, and thus a serious contender for low cost mine-water treatment and recovery.

Estimated cost: R1 033 000
Expected term: 2012 - 2015

Investigation of carbon flux and sulphide oxidation kinetics during passive biotreatment of mine water
University of Cape Town
No. 2139

Mine wastewaters generated during active operations or resulting from groundwater rebound at abandoned sites will have major environmental and economic implications for South Africa in the medium and longer term, particularly as active dewatering of some underground basins ceases. Active treatment of the wastewaters, involving oxidation, neutralisation and sedimentation, is the most widely employed technology. However, active systems are not appropriate for all scenarios, particularly lower-volume discharges in remote areas. For these waters there has been increasing interest in biological treatment processes, particularly passive or semi-passive systems. These rely on naturally-occurring biological and geochemical processes to improve water quality with minimal operational and maintenance requirements. In order to understand and therefore apply such systems, this project will (1) characterise the packing of lignocellulosic material in the degrading packed bed reactor (DPBR) to facilitate estimation of void volume, flow patterns and hydraulic retention time, (2) investigate carbon flux through the DPBR and linear flow channel reactor (LFCR), where sulphide oxidation takes place, to determine whether additional supplementation with readily accessible carbon (e.g. molasses) is required and, if so, at what rate, (3) determine the rate of release of phenolic compounds from lignocellulosic material in the DPBR and evaluate potential inhibition of sulphate-reducing bacteria (SRB) (4) develop a one-dimensional unsteady-state mass transport model to describe the upward diffusion of sulphide and downward diffusion of oxygen through the

biofilm, and (5) refine the existing oxygen requirement model to account for impeded diffusion as a result of the biofilm.

Estimated cost: R279 450
Expected term: 2012 - 2013

A detailed acid-base accounting study of the Karoo formations in the Waterberg coalfield
University of the Free State (Institute for Groundwater Studies)
No. 2142

Coal mining has a pronounced impact on surface and groundwater quality and quantity. Local experience indicates that the influx of water may be as low as 1% of rainfall for deep bord and pillar mines with no subsidence, to as much as 20% for some opencast mines. Such differences have significant impacts on the quantity and quality of surface and groundwater resources in a local area and further afield. The Waterberg is the only remaining large area with proven coal reserves in South Africa and they are being targeted for large-scale mining in the foreseeable future. Most of this will be opencast mining, resulting in large volumes of spoils and also discards (due to the fact that a number of coal seams will be mined with approximately 50 m of interburden between the coal layers) being handled on surface. This project will provide detailed in-depth acid-base potential studies in the area in order to determine how spoils should be handled in future by the mining companies, due to the complexity and volume of the spoils and discards. If handled correctly, acid generation can be minimized. This study will consolidate the existing information, and obtain new information regarding the possibility of acid generation of the overburden, interburden and discards.

Estimated cost: R1 775 000
Expected term: 2012 - 2014

THRUST 6: WATERSMART FUND

Programme 1: Watersmart fund

Development and testing of a water treatment bottle for use during emergency diarrhoeal outbreak conditions
University of Johannesburg
No. 2194

Although there are various commercial water treatment options available for the treatment of water under severe circumstances, most of these are dependent on a consumable(s) and equipment that needs to be delivered to the people. When the consumables run out the water treatment also comes to a standstill leaving the people without treated potable water. The ideal would be to provide a water treatment device that can be used with commercially available options, home-based chemicals or, in extreme situations, things we find in the environment. In an attempt to come up with a design that could provide an option to deal with all these situations, members of the Water and Health Research Centre designed a water bottle that can be used for the treatment of smaller volumes of water (less than 1 L) in all of the above contexts. A prototype of the design has been produced to ensure that everything, in terms of the design itself, is in order before the water bottles go to the production and testing stage. Initial tests, such as testing of the flow rates, effectiveness of filtration materials, etc., have been done in the laboratory to ensure that the design is as close to manufacturing standard as possible. The novelty of the water bottle lies in the fact that the design allows for various applications and adaptations without any structural changes needed.

This literally means that the user can adapt the use to suit what they have available at that stage. The design now gives the user the freedom to transport treated drinking water while having the facility available to treat more water. It can be used by people living in areas without treated potable water, hikers or in emergency situations where treated water might not be available.

The combined aim of this study is to produce the water bottle using injection moulding and to test the effectiveness of the water bottle using a variety of commercially available treatment options, household-derived treatment options and worst case scenario water treatment options.

Estimated cost: R320 000
Expected term: 2012 - 2014

New housing unit designed for ceramic water filters to be more applicable in rural and peri-urban communities in South Africa
University of Venda
No. 2195

In a recently completed WRC-funded study (Project No. 1653) by the University of Venda and the University of Johannesburg ceramic water filters sourced from Ghana were implemented in rural households in the Vhembe District of the Limpopo Province (South Africa). Part of the study involved investigating the extent to which rural communities accepted the filters and what possible changes could be made to increase the efficiency of the filters. It was found that if certain design aspects could be addressed the water filter would be better accepted. This study will test a newly-designed housing unit for the Potters-for-Peace ceramic filter as a point-of-use treatment system in rural and peri-urban communities of South Africa

Estimated cost: R500 000
Expected term: 2012 - 2014

In-field demonstration of a remote, real-time water quality monitoring system
CSIR; Prime Africa Consultants
No. 2196

The aim of the project is to supply data in real time to municipalities so that they can better manage their wastewater quality.

Estimated cost: 250 000
Expected term: 2012 - 2013

Filter for the removal of suspended solids naturally found in harvested water
Durban University of Technology
No. 2197

Rainwater/stormwater has been used as drinking water for at least 6 000 years without harm to the user. However in recent times, with the debatable exception of Australia, authorities worldwide have not been inclined to fully approve private rainwater harvesting as an alternative to piped municipal water, due to skills shortage, and reliance on the self-discipline required for adequate maintenance and water quality. What is plainly evident is that none of the research done thus far has sought alternatives to conventional first-flush methods, relying instead on using either diverter or secondary settlement tanks or in the case of industrial application pressure or sand filtration. This study will be the first research into alternative self-maintaining methods of filtering rain water. The motivation for this research is based on the shortcomings of rainwater harvesting practices internationally. In short the reluctance to

approve the use of rain water domestically is based on research covering all aspects of harvesting water, such as biological, atmospheric, and maintenance problems, and reported dangers to the health of the user. The novel filter is an alternative method of rain water filtration which has been designed to overcome most if not all of these problems. Access to good quality potable water is becoming a universal challenge. Water is a limited resource and being a water-scarce country, South Africa is no exception to this trend.

Estimated cost: R426 400
Expected term: 2012 - 2013

Developing a low-flush latrine for application in public schools
Partners in Development
No. 2198

In May 2011 eThekwini Metropolitan Municipality asked Partners in Development to consider developing a low-flush latrine which could be used in public schools. This study will design and test a robust low-flush system to contribute to the development of a range of on-site sanitation options which take into consideration the full life cycle of a system, including user behaviour, pit emptying and beneficial disposal of sludge.

Estimated cost: R250 000
Expected term: 2012 - 2013

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KSA 4: WATER UTILISATION IN AGRICULTURE

DR GERHARD BACKEBERG | EXECUTIVE MANAGER

KSA 4: WATER UTILISATION IN AGRICULTURE

SCOPE

Utilisation and development of water resources in agriculture must be analysed in relation to the needs and requirements of people. People using water in agriculture comprise a diverse group of subsistence, emerging and commercial farmers within the following inter-related sub-sectors of agriculture:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

Water users in all of the above-mentioned subsectors, as well as organisations such as WUAs, cooperatives, agri-businesses and government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life opportunities and problems experienced primarily by water users and related organisations, for irrigated and rain-fed crop production, fuel-wood and timber production as well as livestock and fish production. The problems which may be experienced in practice for any aspect of water use on the farm, irrigation scheme or river catchment vary from non-existence of knowledge, doubt regarding the applicability of existing knowledge, deviation of empirical observations from some relevant theoretical optimum, to an unclear outcome of possible alternative decisions and actions.

Research as a dynamic, creative and problem-solving process must provide information, technologies and models, which can be applied by present and future generations of water users. The overall objectives are to utilise scarce water resources efficiently, beneficially

and sustainably to increase household food security and farming profitability, and thereby increase economic and social welfare, i.e., efficient growth and equitable distribution of wealth on a farming, local community and regional level. These objectives must be achieved through the creation of knowledge by means of research and dissemination of knowledge, technology transfer, training and extension. Traditionally, contributions are made by scientists in applied disciplines or focus areas of soils, crops, engineering, climatology, economics and sociology. Increasingly, however, the complexity of the information needs of water users requires a multidisciplinary or interdisciplinary research effort. In all instances the priorities are enhancement of management abilities in order to improve the efficiency of water utilisation for agricultural and food production.

OBJECTIVES

The **primary objective** is to increase national and 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 and productivity of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection, restoration and reclamation practices.

THRUSTS AND PROGRAMMES

The research project portfolio for 2012/13 is organised within the following thrusts:

Thrust 1: Water utilisation for food and fibre production
Thrust 2: Water utilisation for fuel-wood and timber production
Thrust 3: Water utilisation for poverty reduction and wealth creation in agriculture
Thrust 4: Water resource protection and reclamation in agriculture

The scope of the strategic thrusts and programmes within KSA 4 is as follows:

KSA 4: WATER UTILISATION IN AGRICULTURE

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	Scope: 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	Scope: 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	Scope: 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	Scope: 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	Scope: 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	Scope: 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	Scope: Agricultural decisions to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, have 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.

BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed funding budget of R27 385 896. The consolidated research project budget for the research portfolio is presented below:

Research portfolio	Approved 2012/13 (R)
Current projects	24 385 896
New projects	3 000 000
Total	27 385 896

CORE STRATEGY

Strategic context

The National Planning Commission released the National Development Plan and Vision for 2030 on 11 November 2011. The most relevant sections which direct the Research and Development (R&D) Strategy of the Key Strategic Area (KSA) on Water Utilisation in Agriculture are **first**, 'Key drivers for change' of science and technology; **second**, 'Economy and employment' in relation to the National System of Innovation and Learning that permeates society and business; **third**, 'Economic infrastructure', in particular water resources and services; **fourth**, 'Inclusive rural economy', regarding trade-offs and risks for agricultural expansion; and **fifth** 'Improving education, innovation and training', with a focus on achieving the vision for 2030.

In the Programme of Action of The Presidency (2010), there are two outcomes which give further strategic direction to research in the KSA. Under Outcomes 7 and 10, the following outputs are specifically relevant:

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all:

- Output 1: Sustainable agrarian reform
- Output 2: Improved access to affordable and diverse food
- Output 4: Improved employment opportunities and promotion of economic livelihoods
- Output 5: Enabling institutional environment for sustainable and inclusive growth

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced:

- Output 1: Enhanced quality and quantity of water resources
- Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmosphere quality
- Output 3: Sustainable environmental management

Furthermore, the Green Paper on National Strategic Planning (2009) seeks to answer, amongst others, how to reduce poverty and what capacity is needed to ensure availability of water, energy and food in the future. The intention is to articulate a vision and strategy for the next 15 years, to which all organisations of Government are aligned. In this regard the South Africa Vision 2025

of the Medium Term Strategic Framework projects a society in which, inter alia:

- People are united in diversity while appreciating the common interest that binds them together
- Conditions have been created for full participation of women
- Effective programmes exist to reduce poverty and protect the most vulnerable in society
- Beneficial and sustainable use is made of human resources, natural resources and modern technology
- Common interests are promoted by investment and competitive returns for the private sector

People-centred research and development for poverty reduction, productive use of natural resources and technology, with competitive growth in agriculture, have been key elements of the core strategy of the KSA, as presented in previous years and again elaborated below.

In addition, the strategic context for research on water utilisation in agriculture was given renewed impetus by a 2008 report of the National Agricultural Marketing Council (NAMC), which serves the strategic positioning of South African agriculture. It was reported that food production had not kept pace with consumer demand, mainly driven by population growth and increasing per capita income, leading to food price increases. Several factors had contributed to the poor performance, including adverse climatic conditions, lack of availability and quality of water, and low profitability with lack of investment because of high input costs and insufficient progress to increase productivity. The report highlighted the importance of making available adequate water and fertiliser production inputs and of improving agricultural support through research in order to increase food production.

The water resource base is therefore 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 abundantly clear that the biggest share of water is used for both extensive and intensive production in agriculture.

The significance of agriculture and the impact of research in the development process encompass the following:

- Everybody in society consumes food. Technological progress in agriculture therefore has widely distributed benefits.
- Agriculture is the key to poverty reduction in rural areas. Water resource use and production should be analysed as a value-adding process (from farmer to consumer) and the business and employment opportunities which are created should be recognised.
- Research increases the productivity of natural and human resources. This improves the competitive advantage of agriculture in a global economy.

In South Africa, at most 35% of the economically active population are directly or indirectly dependent on

agriculture, although this percentage is declining each year. 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. Estimates also show that 48.5% of the population are living below the poverty line of which 70% are in rural areas. According to the HSRC (2009) about 4.5 million Black people (or 9% of the population) in South Africa participate in agriculture in some form, mainly livestock production. Many of these are involved in low-input, low-output farming activity that provides supplementary food for households. Recent data from various surveys indicates that 52% of households experience hunger and, with a monthly income poverty line of R1 200, 59% of households are food insecure.

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. Until 2006 agriculture was also a net exporter of food, contributing 10% of total exports of which 50% are processed products. During 2007, imports exceeded exports, mainly due to import of processed food products. Since 2008 the trade balance is again positive.

The abovementioned current reality of agriculture in South Africa was also clearly stated by the Department of Water Affairs and Forestry (DWAF) in the strategy, Water for Growth and Development in South Africa (2008) (Version 7). Effective change in water use behaviour to promote water savings for growth could be achieved through incentives to improve irrigation efficiency and conservation practices. These include water measuring and user charges as tools to manage demand, upgrading irrigation technology and trading of water use entitlements. Revitalisation of irrigation schemes in the former homelands is required for household and community level irrigation. Furthermore it is important to provide water for food production in home gardens in rural villages or towns and peri-urban areas. This can be done through development of small-scale infrastructure for different forms of rainwater harvesting and storage, which promotes rural development.

Critical issues in the forthcoming years and the next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing consumer income levels. Expansion of agricultural production on land suitable for cultivation will be increasingly constrained by the availability of water. Increasing hazards of rainfall variability, with western parts of South Africa getting drier and eastern parts wetter, over the long-term, are caused by climate change. This requires adaptive management practices to reduce the vulnerability of people in rural areas and prevent disasters of crop failures, income loss and widespread famine. At the same time, there is a relatively high ratio of people to cultivated land and a larger dependence on agriculture in rural areas to increase material income and improve social wellbeing, 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 restoration and 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 with research and development must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background it is important to emphasise that the strategic focus of water research in this KSA, which was also found to be relevant by the July 2006 External Institutional Review, continues to be on:

- Increasing the efficiency and productivity of water use for food, forage, fibre and fuel production (i.e. improving the knowledge of biological, technical and economic processes of production)
- 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)
- 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)

Needs analysis

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, Agri SA and the National African Farmers Union (NAFU), and is currently being revised. 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 three 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 (CAADP) of the New Partnership for Africa's Development (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 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. agri-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".

In the biannual *Overview of the World Food Situation* by the International Food Policy Research Institute (IFPRI) at the end of 2007 it is stated that renewed attention must be given to agriculture, nutrition and health in adjusting research agendas. Strategies must be directed at poor members of society. In this regard social security measures must be taken that focus on early childhood nutrition, particularly of poor households. With increasing risks caused by climate change, more investments must be made in agriculture to improve productivity. This includes investment in agricultural science and technology to facilitate a production response to rising food prices.

At a conference on Nutrition and Food for Special Dietary Uses, held in Cape Town at the beginning of November 2008, the Minister of Health stated that "food insecurity and high rates of malnutrition, coupled with high food prices, remain the biggest threat to nutrition in Africa". More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices.

Specific recommendations by DWAF (2008) to promote water for growth and development of agriculture were: measurement of water; correct scheduling and implementation of appropriate technologies to enhance efficiency and to reduce the amount of water used for irrigation; re-establishment of high-value crops under irrigation in areas where production can be supported on a sustainable basis; revitalisation of irrigation schemes and exploring, developing and using groundwater for small-scale irrigation on household and community food plots; and investment in small projects for rainwater harvesting and conservation in rural areas.

During 2009 the Minister of Water Affairs raised three key issues which are directly relevant to the KSA: first, the need for incentives, technologies, guidelines and training for rainwater harvesting; second, the need for awareness, knowledge, education, compliance and enforcement to prevent water pollution; and third, the need to disaggregate models and enable intervention at a local level to improve agricultural productivity with climate change under conditions of water stress.

In the 2009 Budget Vote, the Minister of Agriculture, Forestry and Fisheries emphasised the Comprehensive Rural Development Programme (CRDP). This will enable people in rural areas to meaningfully participate in the economy through the productive use of natural resources at their disposal and thereby effectively reduce poverty. Specific mention was made of the need and commitment to train extension officers. Regarding forestry, the Million Trees Programme and Livelihoods Programme encourage the planting of trees and harvesting of firewood, building material, medicinal plants and edible fruit to address the basic needs of the rural poor. It was also stated that the declining fish stocks must be managed by development and sustainable use of natural resources.

The consultation with stakeholders during 2009 highlighted the following priorities which are relevant to the KSA: water security; poverty alleviation; trade-offs between food and bio-fuel production; efficiency of water use and improved measuring tools; the water footprint of agriculture; water shortages and drought; and the impact of climate change.

The review of the strategic plan for **agriculture**, which was completed in 2008, identified a number of concerns: limited capacity within Government, slow

pace of implementation and inadequate funding for critical programmes, such as food security. In the case of **forestry,** the multiple benefits of woodlands, forests and plantations and their contributions to the economy, society and environment are acknowledged. This requires flexibility to respond to community needs, incorporate water catchment management principles and utilise commercial and other opportunities for woodlands and plantation forestry. For **fisheries,** high demand for access to resources must be balanced with requirements of environmental sustainability, given the opportunities for economic and social development.

For the purpose of Integrated Growth and Development Planning (IGDP) (2010), a range of current realities and challenges are discussed. Amongst others, factors such as the lack of access to land, water, markets, finance, infrastructure, education, skills development and flow of information, will prevent marginalised members of society from making substantive progress in farming, forestry and fisheries across the entire value chain. It is argued that a driver of economic growth of these sectors and the related productivity has been the support provided through research and technology development for water resource management, risk management, natural resource management, seed and cultivar breeding programmes, due to public investment in research and development (R&D). However, existing organisations involved in R&D have major capacity constraints and experience difficulties in acquiring and retaining scientists. It is maintained that R&D projects are not co-ordinated, are not aligned to industry and Government priorities and that inadequate funds have been allocated to R&D.

The vision for the IGDP is 'an equitable, productive, competitive, profitable and sustainable agriculture, forestry and fisheries sector'. The mission will be developing and sustaining a sector that contributes to:

- Economic growth and development
- Job creation
- Rural development
- Sustainable use of natural resources
- Maintenance of biodiversity and ecosystems
- Sustainable livelihoods
- Food security

One of four sector challenges is environmental/ ecological sustainability and the related sector goal is formulated as 'improved, sustainable natural resources management', with specific focus on the protection of scarce and threatened resources, e.g., water, soil and fish stocks. The interventions include recognition of the importance of freshwater systems to the sector and integrating them as a key component of the IGDP. Funding should be sourced for research directed at natural resource issues and conducting cooperative research to address the research implementation gap. In this regard applicable activities are water conservation and water demand management for agriculture, forestry and fisheries, in particular water use efficiency systems for irrigation.

According to the National Planning Report (2011), "science and technology (S&T) are key to development, because technological and scientific revolutions underpin economic advances, improvements in health systems, education and infrastructure." Therefore, access to and application of, knowledge are critical. "S&T are the differentiators between countries that are able to

tackle poverty effectively by growing and developing their economies, and those that are not. Innovation is the primary driver of technological growth and drives higher living standards. To promote technological advances, developing countries should, amongst others, ensure that knowledge is shared as widely as possible across society." "In societies that have large stocks and flows of knowledge, virtuous circles that encourage widespread creativity and technological innovation emerge naturally, and allow sustained growth over long periods. The investment climate is crucial, as are the right incentive structures, to guide the allocation of resources, and to encourage research and development (R&D). A substantial R&D sector, with support into commercialisation is essential. A well functioning research capacity is critical to sustaining growth and improving productivity. South Africa's competitiveness will rely on national systems of innovation, permeating the culture of business and society. Public policy could focus on R&D in existing areas of competitive advantage, where global markets are set to grow. These include high-volume agriculture and downstream processing." "The national system of innovation, the education system and private industries should create a common overarching framework to address pressing challenges. Special consideration should be given to dedicated programmes in water, amongst others, in which South Africa has both comparative and competitive advantage."

These relevant needs and priorities as expressed by Government, public organisations and stakeholder representatives, at national, regional and international levels, are all receiving attention in the Research and Development Strategy of the KSA. As in previous years, they will guide the selection of topics for expansion of projects in the research portfolio and can be summarised under the following key activities:

- Increasing the productivity of rainwater and irrigation water for crop and livestock production
- Uplifting rural economies through commercial food production
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving nutrition and health
- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

Overview of technological trends

In the book *The Necessary Revolution* (2008) it is argued that "previously taken-for-granted aspects of daily life – food, water, energy, predictable weather – seem less and less reliable". The reasoning continues that "if we see each problem – be it water shortages, climate change or poverty – as separate, the solutions will be short-term, doing nothing to address deeper imbalances. The first imbalance concerns nature's capacities to regenerating resources and providing the 'eco-services' upon which human life depends – clean water, breathable air, fertile soil, pollination and a stable climate". It is stated that the "diminishing resources and growing waste underlie a host of economic stresses and reflect environmental and social imbalances that all but ensure that, without significant change, these problems will worsen". Consequently a shift in thinking is required to start a revolution that can transform society. This pre-supposes

that core capabilities must be acquired of observing and analysing systems in practice, collaborating across disciplinary boundaries and creating a new reality instead of finding opportunistic, 'quick-fix' solutions.

In the KSA explicit efforts will consequently continue to stay at the forefront of new technological developments and promote 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 to achieve socially and economically beneficial outcomes. A balance must therefore continuously 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., water measurement, 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 subsectors of agriculture to reduce costs and to increase income.

In particular, attention will continue to be given to rain-fed agriculture and the existing technologies which have been developed for water harvesting in Sub-Saharan Africa. The 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 New Partnership for Africa's Development (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.

According to the National Agricultural Research and Development Strategy by the Department of Agriculture (2008), a key area for technology development is sustainable natural resource management. The statement is made that: "Farmers maximise income and risk in a dynamic context and often under harsh conditions and serious constraints. Research must respond to these challenges through inclusion of technologies to address sustainable natural resource management. This would include technologies to address soil erosion degradation, nutrient depletion, loss of bio-diversity, prevention of invasion by alien species, maintenance of water quality and veld productivity,

optimisation of water use efficiency under both irrigated and rain-fed conditions, capturing and storing rainwater (rainwater harvesting) and restoration or creation of new balances in biotic communities. Geographic Information System-based technologies, natural resource inventories and adequate characterisation and monitoring are considered essential."

Together with a growing population and high degree of food insecurity, there is increasing competition for water and uncertainty about future water availability. Major questions arise, such as: what is the role of land use and water use changes on water availability and how does managed land use affect consumptive water use? There is a need to separate non-beneficial soil evaporation and beneficial plant transpiration. This also leads to questions on water productivity; in particular, how much food is produced in rain-fed and irrigated agriculture and what are the ranges of water productivity for food, forage, fibre and fuel crops? Water accounting from satellites is an innovative step towards standardised description of water resources. The water accounting framework links water users with the process and benefits of land use. Satellite images ensure data flow on changes in water use. This will enable quantification of beneficial and non-beneficial use for different land use classes.

Under the heading 'Anticipating and addressing strategic issues and trends', published in the Green Paper (2009), the following national planning issues are mentioned which could be subject to ad hoc investigations:

- Long-term availability of water
- Energy consumption and production
- Conservation, biodiversity, climate change mitigation and adaptation
- Food security and sustainable rural development
- Innovation, technology and equitable economic growth
- Poverty, inequality and the challenge of social cohesion
- National health profile and developmental health care strategies

The Green Paper envisaged that a national plan would be developed by 2010 with expert panels advising on issues such as food security, water security, energy choices, economic development, poverty and inequality, climate change, human resource development, social cohesion, health profiles and scientific progress. This task has been accomplished with publication of the National Development Plan (2011). Under the section dealing with 'Water resources and services', it is stated that for 2030 the vision is that "the country's economic and social development will reflect an understanding of and an alignment with available water resources. As a result, all main urban and industrial centres will have a reliable supply of water to meet their needs, while increasingly efficient agricultural water use will support productive and inclusive rural communities. The natural water environment will be protected to prevent excessive abstraction and pollution." For the purpose of water conservation and demand management "reducing demand, rather than just increasing supply, is important." "Agriculture uses the largest volume of water (albeit at far lower levels of reliability than urban and industrial uses). As a result, the farming sector will have to increase the efficiency of its water use to expand production and allow transfers to other users in water-scarce areas, as well as for expansion in irrigated agriculture. The commission proposes a dedicated national programme to provide support to local and sectoral efforts to reduce water demand and improve water-use efficiency. Water-saving and demand-management projects should be

considered as part of the overall range of water supply investment programmes. These can be compared with supply expansion projects, and should be prioritised accordingly, based on their merits." This support for increased water use productivity and potential water saving can indeed be provided with integrated implementation of the management systems, models and tools from river catchment to irrigation scheme level, to farm and field level, developed through WRC research projects and already applied in practice.

Under the heading 'Trade-offs and risks for agricultural expansion' it is recommended that, amongst others:

- "Investing in water resource and irrigation infrastructure where the natural resource base allows, and improving the efficiency of existing irrigation to make more water available.
- Providing innovative market linkages for small-scale farmers in the communal and land reform areas, with provisions to link these farmers to markets in South Africa. This will require infrastructure to improve the time and place utility of farm products through road, rail and communications infrastructure that gets the products from the farm gate through the different stages of the value chain.
- Creating tenure security for communal farmers. Tenure security is vital to secure incomes for all existing farmers and for new entrants. Investigating the possibility of flexible systems of land use for different kinds of farming on communal lands. However, as long as these farmers (especially women farmers) do not have secure tenure, they will not invest, and agricultural production will not grow at the rate and pattern required for growth in employment.
- Supporting innovative public-private partnerships. South Africa's commercial farming sector is full of examples of major investments that have resulted in new growth, and new job opportunities.
- Recognising the consequences of industrialised agriculture and the country's unique ecosystems, which also demand that serious attention is paid to advances in ecological approaches to sustainable agriculture. This includes greater attention to alternative energy, soil quality, minimum tillage, and other forms of conservation farming.
- Improving and extending skills development and training in the agricultural sector, including entrepreneurship training. This should include the training of a new cadre of extension officers that will respond effectively to the needs of small-holder farmers and contribute to their successful integration into the food value chain.
- Increasing and refocusing investment in research and development for the agricultural sector. Growth in agricultural production in South Africa has always been fuelled by technology, and the returns on investment in agricultural research and development have always been high."

In the research portfolio of the KSA: Water Utilisation in Agriculture of the WRC, different aspects of all these strategic issues are being researched. These are, in particular, water use in food value chains; land and water use security for empowerment of women; models for public-private-partnership, such as for rural freshwater aquaculture; investigating water use for bio-fuels and bio-gas as sources for alternative, renewable energy; up-scaling rainwater harvesting and conservation to

croplands; developing training material for improving the capabilities of extension officers regarding irrigation water management on smallholder schemes; and determining entrepreneurial development paths for productive water use by smallholder farmers. The available and future research output of the KSA is therefore positioned and geared to make a constructive contribution by responding to the recommendations and achieving the vision for 2030 of the National Planning Report.

Key stakeholders

This KSA clearly supports South African Government strategies and initiatives where water conservation, in particular, water development and utilisation for agriculture, is of concern. Government departments, especially the Department of Water Affairs (DWA) and the Department of Agriculture, Forestry and Fisheries (DAFF) are important stakeholders. These links have also been formalised by the support of selected projects of mutual interest through leveraged funding. In addition, district municipalities, provincial departments of agriculture, water user associations (WUAs), catchment management agencies (CMAs), cooperatives and agribusinesses, are all stakeholders with whom the WRC is engaging. In all cases co-operation is achieved by invitations to review research proposals and to serve on the reference group of relevant research projects as well as research project related cooperation.

Key stakeholders and beneficiaries of this KSA remain as previously described. These are farmers who are represented by Agri SA and NAFU. It is estimated that there are 35 000 commercial farmers, 250 000 emergent farmers and 4.5 million subsistence farmers.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies has been designed by formalising stakeholder relationships. This is gradually being implemented 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 have largely remained the same as in previous years, and are the provincial departments of agriculture (PDAs), the DAFF mainly through its Directorate: Water Use and Irrigation Development and DWA through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC are firstly, and, inter alia, an initiative by the DAFF to give policy direction to development through integrated water management for agricultural use and implementation of the irrigation strategy, and, secondly, the water conservation and demand management strategy in agriculture, the water allocation reform strategy and the broad-based black economic empowerment guidelines for water use that DWA is implementing.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The Integrated Development NPA 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 eight 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.

KSA 4: WATER UTILISATION IN AGRICULTURE

Globally the International Water Management Institute (IWMI), as a member of the Consultative Group on International Agricultural Research (CGIAR), 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. Research is done under four themes: water availability and access; productive water use; water quality, health and environment; and water governance.

The CGIAR Challenge Programme on Water and Food (CPWF) is an international, multi-organisational research initiative. The partnerships seek meaningful impacts for people who use innovations developed by scientific research. Its goal is to increase the productivity of water used for agriculture, leaving more water for other users and the environment. In the Limpopo basin, the development challenge is to improve rural livelihoods through better management of rainwater, including management of small dams.

Providers of research

The main suppliers of research projects are universities and colleges (currently Universities of KwaZulu-Natal, Pretoria, Free State, Stellenbosch, Rhodes, Fort Hare, Cape Town, and North-West, and the Tshwane and Cape Peninsula Universities of Technology); science councils (various institutes of the ARC and CSIR Natural Resources and the Environment); as well as established and emerging private consulting groups.

RESEARCH PORTFOLIO FOR 2012/13

In this KSA a holistic systems approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Research projects are managed within the innovation cycle to ensure that scientific research is applicable and socially beneficial. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to Vision for 2030 of the National Development Plan; the outputs for Outcomes 7 and 10 in the Programme of Action announced by the Presidency; the Green Paper on National Strategic Planning; the DWA framework, Water for Growth and Development (Version 7); the DAFF Integrated Growth and Development Plan; the National Agricultural Research and Development Strategy; and the Comprehensive Africa Agricultural Development Programme of NEPAD. Work will continue to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following key activities of the research portfolio:

- Increasing the productivity of rainwater and irrigation water for crop and livestock production
- Uplifting rural economies through commercial food production
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving nutrition and health
- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

Over the past 10 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 toward practical application of results with technology transfer projects. An overview of completed projects and stakeholder requirements indicates the direction and priorities for future research.

COMPLETED PROJECTS

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

Baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security
University of Pretoria; Human Sciences Research Council; Medical Research Council
No. 1954

The general objective of the project was to determine nutritionally important foods for the diet of rural households in South Africa, with specific reference to the poor; and to describe the nutrient content and water use of related unprocessed crop and animal products using existing knowledge. This exploratory project was a desktop study that systematically examined the literature available. The report shows that whilst certain general trends have become apparent, there seems to be insufficient available evidence to compile one basket of contemporary food intake of poor households in rural areas of South Africa. Purchasing of staple foods seems to be the most important source, but regarding the foods of which intakes appear to be low (foods of animal origin, fruit and vegetables), and which could potentially be home-produced, there is limited evidence of its source, including seasonality. The report also shows that information on the reasons for the foods consumed by rural South Africans is sparse and fragmented. Based on dietary as well as biochemical indicators, key micronutrients lacking in the diet are Vitamin A, iron and zinc, which relates to low consumption of foods of animal origin, fruit and vegetables. The report includes an in-depth discussion of the nutrient composition of two crops, orange sweet potato and dark green leafy vegetables, as a sub-group. Initial benchmark estimates of nutritional water productivity (NWP) for key nutrients of selected crops (cereals, legumes, fruit, dark green leafy vegetables, and yellow/orange vegetables) and animal food products were made. Gaps in existing knowledge and research were highlighted and the foundation for follow-up research was laid.

Cost: R1 000 000
Term: 2010 - 2012

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 (Department of Food Science); University of Pretoria (Virology); University of Venda; University of KwaZulu-Natal (Pietermaritzburg)
No. 1773

There is a growing concern about the 'safety status' of South African agricultural produce, especially

that which is consumed raw. If these products are contaminated they will impact not only the health of the final consumer but also that of people living next to rivers and the producers. This will immediately impact both national and international trading status and cause a suspension of exports. Furthermore, there were, and still are, regular articles in the local press reporting on the shocking environmental status of local rivers. The source of contamination of the agricultural products was identified as irrigation water that had been contaminated before irrigation took place. The health risks associated with the use of contaminated irrigation water on agricultural products thus became an increasing concern. The main objective of this solicited research project was to do a quantitative investigation into the link between irrigation water quality and food safety. Results indicated that the microbial pollution levels of rivers and fresh produce monitored at selected sites in different provinces of South Africa over a period of 3 to 4 years were of an unacceptable standard and did not meet either the international or national guidelines for safe irrigation or human consumption. Other potential waterborne bacterial, virus and protozoan pathogens were frequently recovered from both the water and the produce. It was concluded that there is a high risk of exposure to pathogens when water from these rivers is used to irrigate produce that is consumed raw or without any further processing steps. In the research it was shown using phenotypic and genotypic identifications that direct water to produce linkages could be made. It was concluded that species from the surface of produce were present as a result of transfer from the contaminated irrigation water. There can now be no doubt that specific carry-over does take place. The potential of pathogenic organisms to be transferred from irrigation water to the surface of fresh produce plus their ability to survive in these unfavourable conditions presents a scenario where consumers unknowingly face a high risk of being infected with harmful organisms when consuming fresh produce. Various recommendations for further research are made ranging from distribution profiles of pathogenic bacteria, seasonal variations and monitoring in irrigation water, development of effective quality assurance measures for detection of enteric viruses to investigation of effective on-farm treatment options for contaminated irrigation water.

Cost: R5 232 500
Term: 2007 - 2012

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

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; ARC (Institute for Animal Production); ARC (Institute for Soil, Climate and Water)
No. 1478

The aim of this project was to select and implement water harvesting and conservation techniques that would assist two rural communities (Guquka and Khayaletu) in the Eastern Cape to improve their livelihoods by increasing their food production and developing their rangeland/livestock production systems. On-station and on-farm field experiments were conducted in order to test rainwater harvesting and conservation (RWH&C) techniques. The results showed that subsistence farmers in the semi-arid areas

could improve maize yields considerably by replacing their conventional practices with in-field rainwater harvesting (a specific form of micro-catchment water harvesting) without cover crops and, if possible, applying mulch on the basin and runoff areas. This would improve their level of food security. The project found that if the intention of small-scale farmers is only to produce well-balanced fodder in bulk for their animals or fodder for their animals as well as food for the household, then the IRWH treatments with cover crops might be a good option. It is evident from the research findings that using micro-catchment water harvesting in combination with either mulch or brush improved moisture retention enhancing productivity both in croplands and rangelands. Land tenure and ownership are major challenges in both croplands and rangeland, and thus affect the management of these resources. The IRWH technique was used by village members of two villages in the Eastern Cape, Guquka and Khayaletu, to greatly improve their household food security.

Cost: 5 200 000
Term: 2004 - 2012

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 (Department of Agricultural Economics); ARC (Institute for Soil, Climate and Water); University of Fort Hare
No. 1648

The point of departure for this research was 'an assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities'. The main objective was however stated more humbly as 'to evaluate the social, economic and institutional determinants of sustainable rainwater harvesting and conservation (RWH&C) techniques and practices'. With the Sustainable Livelihoods Framework (SLF) as theoretical basis, the main objective was achieved through 16 specific objectives with a focus on evaluating the five capitals, natural, physical, financial, human and social, of the SLF utilising Participative Active Research (PAR) as the main research methodology. It can generally be concluded that all the five capitals proved very important for the sustainable adoption of selected RWH&C practices and techniques. Each must be known and evaluated on its own and then in conjunction with all others taking characteristics, adequacies, limitations, etc., into consideration. The natural capital (soil, climate, etc.) must, for instance, as a point of departure, be suitable for implementing specific RWH&C practices and techniques. If this is not the case it is not worthwhile attempting to implement action. In three villages, Potsane, Rietfontein and Cata, the natural capital is fairly good while in Kwezana-West the lower annual rainfall is, for instance, a constraining factor in the application of some of the RWH&C techniques, like IRWH. Thereafter the physical capital must be evaluated and followed by describing, analysing and evaluating the financial, human and social capital. Although each capital on its own is very important, the interactions amongst all capitals are equally important and must be known to identify competitive, supportive and synergistic relationships. In this regard the human and social capitals play an overarching role but these are relatively much more complex than the other capitals and very difficult to understand, assess and evaluate. The lessons learnt and recommendations reported provide guidelines on factors and issues that must be considered/evaluated with regard to the different capitals before venturing into the promotion of RWH&C techniques and practices in other areas. Extrapolating

the findings and recommendations to other areas must however be done with caution given the uniqueness of each area and the complexity of understanding and assessing the different capitals on their own and in conjunction with other capitals.

Cost: R3 100 000
Term: 2006 - 2012

Programme 2: Integrated water management for profitable farming systems

Development of training material for extension in irrigation water management
University of Pretoria (Department of Agricultural Economics, Extension and Rural Development); Lowveld College of Agriculture; PICWAT
No. 1649

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 especially smallholder farmers, are dependent on extension services as a source of information and knowledge. 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 become less effective. In 2005 a consultancy project was undertaken for the WRC to establish a database of extensionists who are active on smallholder irrigation schemes in South Africa. In that process it was also determined that the current level of training presented by tertiary organisations to extension workers for the tasks they have to perform on irrigation schemes is inappropriate in the majority of cases. The outcomes of this consultancy project formed the basis for the solicited research project. The aim for this project is to develop and interactively test learning material for the capacitating of extensionists in the promotion of efficient use of irrigation water by smallholder farmers. The main output of this research project was the development of the learning material for the eight learning areas that were identified to form the 'knowledge profile' of the irrigation extensionist. The aim of the learning material is to support tertiary training organisations like agricultural colleges and universities of technology offering agricultural programmes on NQF Level 5, as well as to support training providers offering short courses in irrigation management. The learning package consisting of nine parts is aimed to help build the necessary skills and competencies required of irrigation extensionists to assist irrigation farmers in the learning process they need to undergo regarding irrigation water management. It is recommended that the outcomes of this project should be marketed and disseminated to all relevant tertiary and private training organisations in the country for future practical training on various aspects of irrigation water management. This will ensure that the lack of competencies amongst extensionists is addressed, and will restore their credibility and self-esteem towards the rendering of a professional service to irrigation farmers.

Cost: R2 370 000
Term: 2006 - 2012

Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement
WSM Leshika Consulting (Pty) Ltd; WRP Consulting Engineers (Pty) Ltd; MBB South Consulting Engineers (Pty) Ltd; NB Systems; Clear Pure Water
No. 1778

The results of this technology transfer project can be summarized in four key messages for potential users of measuring devices for irrigation water:

- Assign the responsibility for implementation to a skilled person: A knowledgeable and skilled person employed by the Water User Association (WUA) or Irrigation Board is required if water measurement is to be implemented successfully. Such a person should preferably have a technical background and be involved with the process of implementation right from the start, to ensure that they share all the experiences in the process of finding a sustainable measurement solution for the area under consideration. This person must be able to develop a measurement system for the specific situation and also be able to see to the day-to-day operation and maintenance of the measuring devices (with assistance if necessary).
- Preparation is key: In order to find the best solution, it is recommended that any possible technology that is being considered for wide-scale implementation must first be evaluated on a trial basis to obtain first-hand experience with its installation, operation and maintenance requirements. It is better to try out as many technologies as possible on a small scale before making a final selection, as this can prevent inappropriate, costly systems from being purchased that may become redundant after a short while of operation. The cost of single units of a few different technologies is money well-spent in view of selecting the best solution.
- Commit to an implementation plan: Any project should be planned and implemented as simply and practically as possible – unnecessary complication is a threat to successful project implementation. This can only be achieved if knowledgeable implementing agents manage the project through careful planning and in-depth assessment of the situation presenting itself, as every project will be different in its own right and therefore require site-specific solutions, an outcome that will hopefully be achieved through the careful application of the proposed implementation guidelines and plan.
- Install the most appropriate technology that can be afforded: Research work undertaken over the past 10 years has shown that suitable technologies and devices are available for the measurement of irrigation water, even in challenging situations with regards to aspects such as water quality and installation conditions. Failure of measuring devices or systems can usually be blamed on incorrect selection, application, installation or maintenance rather than on the technology itself. Under demanding conditions, it is imperative that the best technology or device available and affordable is obtained, to ensure a sustainable system that will serve the purpose that the owners of the system intended it for. The benefits of a suitable system will ensure that it pays for itself within a short period of time but an unreliable system will only cause frustration and lead to unnecessary expenses and an additional work load on the water managers of a scheme.

Cost: R1 800 000
Term: 2007 - 2012

Assessment of the contribution of water use to value chains in agriculture
University of the Free State (Department of Agricultural Economics)
No. 1779

Actual achievements where emerging farmers are successfully operating in commercial agri-food chains are scarce. The small number of success stories means that the objective to allow farmers to improve their livelihoods through irrigated agriculture is not met. It is noted that access to agricultural water plays a necessary role in increasing productivity, but access to water alone is not a sufficient condition to enhance productivity and alleviate poverty. Given the scope of the analysis that was required to meet the objectives of this study, the conceptual framework that was used consists of a problem tree analysis and an integrated New Institutional Economics (NIE) and Structure-Conduct-Performance (SCP) analysis of the three levels (micro, macro and meso) that comprise the value chain within which the emerging farmers are participating. The nature of the conceptual framework requires both qualitative and quantitative analyses. Within the application of the SCP framework, qualitative analyses were used to investigate the physical environment (structure) within which the farmers operate, the way they behave in the physical environment (conduct), and the level of performance in terms of production volumes and income generated. The analysis of the resource allocation level within the NIE framework consists of quantitative analyses of the levels of efficiency with which production inputs are used to generate income. The integrated NIE and SCP framework was applied to three case studies: the case of raisin producers from Eksteenskuil in the Northern Cape Province, the case of vegetable producers from Zanyokwe Irrigation Scheme, and the case of maize and vegetable producers from Thabina Irrigation Scheme. The results from the analyses of the distribution of water use along the value chains show that the bulk of all of the water that is used along the value chain is used at farm level to produce the food products. Efforts to increase the efficiency with which water is used along the value chain thus should focus the attention on water use at farm level. A number of key success factors were also identified from the results of the study that prove to have great potential to contribute towards the successful participation of emerging farmers in commercial agri-food chains. The key success factors include, amongst others, effective support to emerging farmers; effective collective action among emerging farmers; actions to minimise the potential negative impact of cultural activities on the performance of the farm businesses; secure tenure; tailor-made financing schemes; and coordinated efforts to overcome stumbling blocks. The results from this study show that emerging farmers have great prospects to increase their production levels by using their production inputs more efficiently and thereby substantially improve their cash flow positions. It is important to note that the farmers can increase their production at current input levels and within their existing technology set. Based on the findings from the three case studies, recommendations are made for emerging farmers to enhance their ability to successfully participate in commercial agri-food chains, for policy makers to formulate new policies and to adjust some of the existing policies to enhance the successful participation of emerging farmers in commercial agri-food chains, and for future research that needs to be conducted to contribute to the topic of the optimisation of economically beneficial water use by the integration of emerging farmers into the mainstream of the economy.

Cost: R2 430 000
Term: 2007 - 2012

The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile Catchment
CPH Water; University of the Free State; Danish Hydraulic Institute: Land, Water and Health; South African Sugarcane Research Institute
No. 1805

A major modelling achievement of this project is the linkage of hydrologic simulation with economic optimisation to quantify possible impacts of changes in catchment water management scenarios on irrigation farming profitability and livelihoods. Through the development of the integrated hydro-economic decision-making framework the research showed that it is possible to replicate the decision-making framework used by DWA to manage water in the Crocodile East catchment. The developed framework proved to be flexible and the researchers were able to incorporate operating rules that were practised in the catchment. Accommodating these operating rules increased the credibility of the results which enhanced participation and discussions about alternative water management scenarios. Strong participation of stakeholders definitely resulted in an improved modelling framework and better understanding of the issues surrounding catchment water management and the implications thereof for water users. The integrated modelling framework hinges strongly on the outputs from the irrigation module to optimise agricultural water use. This was achieved through the development of an FAO 56 based irrigation module that is integrated with MIKE BASIN on a daily basis. The irrigation module was used to provide the inputs for the optimisation model to optimise water use. Further development of the whole-farm SKELETON model was done through the development of state contingent response functions that are able to more accurately model the impact of different levels of assurance of supply. It is important to note that the state contingent approach increased the dimensionality of the programming model to such an extent that it was collapsed into a single annual time period. Thus, the modelling framework does not allow for dynamic changes in irrigators' response to changes in catchment management over the long-run. Overall, the objectives of the research were achieved to a better than satisfactory extent. The knowledge that was gained through the development of the integrated decision support system provides the basis for more sophisticated developments to model the impact of changes in water management on irrigation farming profitability over the long-run.

Cost: R1 790 000
Term: 2008 - 2012

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Applications of rainfall forecasts for agricultural-related decision making in selected catchments
University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology); University of Cape Town; University of the Free State; ARC (Institute for Soil, Climate and Water); CSIR
No. 1646

The overall objective of this project was to develop and test techniques and models for translating weather and climate forecasts in South Africa into applications for decision support at a range of spatial scales in both

rainfed and irrigated agricultural production and water management, in order to reduce risks associated with the vagaries of day-to-day seasonal climate variability. The report contains an audit illustrating that there is no lack of climate forecasts available for South Africa. Seven case study applications of weather and climate forecasts are presented. One of the specific objectives of this project was to work towards developing a framework for agrohydrological forecasting for South Africa. This was achieved in two phases, the first being in the early stages of the project with emphasis on a research-based framework for an agrohydrological forecasting system for South Africa with the second, building upon the first, moving towards an operational agrohydrological forecast framework. Having utilised climate forecasts for the agricultural sector and developed an agrohydrological climate-driven forecast system, a series of benefit analyses of such forecasts is also presented. The report includes an economic benefit analysis of maize management decisions using seasonal rainfall scenarios, in which a verification study of maize yield estimates from the APSIM model is followed first by an analysis of simulated maize yields and then, more importantly, by a comparative economic benefit analysis of different management decisions. One of the recommendations from this project is that sustained and adequate funding (possibly from multiple sources) be made available for one institution in South Africa to be made responsible for the collation (from different sources) and uniform quality control of climate data, and that these data then be made freely available to all bona fide researchers.

Cost: R5 700 000 (incl. leverage)
Term: 2006 - 2012

CURRENT PROJECTS

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, sub-tropical 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: R5 567 500 (incl. leverage)
Expected term: 2007 - 2014

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 utilization 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: R4 350 000 (incl. leverage)
Expected term: 2007 - 2013

Water use of cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)
No. 1874

In South Africa, the establishment of an economically viable biofuels industry is increasingly becoming a possibility due to technological advances; global commitment to limit greenhouse gases and to reduce global warming; the need to diversify energy supply; and the need to accelerate rural economic growth by the agricultural sector. With diminishing fossil fuel resources and increasing oil prices, attention is being focused on producing alternatives to fossil fuel, with emphasis on the production of biofuels. The Biofuels Industrial

Strategy of South Africa specifies the use of certain crops as feedstocks for bio-diesel and bio-ethanol production. The consideration of a range of crops and cropping systems as feedstocks is necessary, especially those which may produce food and fodder as well as fuel. Furthermore, the evolution of 'second generation' biofuel technologies which allow for the conversion of cellulose (biomass) for biofuel production must also be investigated in terms of water use and potential impacts on the country's food production. Studies on the water use impacts of the biofuels industry on South Africa's limited water resources are urgently required for both local and national water resource planning. A scoping study on the water use of crops/trees for biofuel production (WRC Project No. 1772) provides preliminary results on the water use and growing conditions of limited biofuel crops based on broad climatic parameters and crop bio-physical requirements. The report of this follow-on project will document the water use and optimal growing conditions for a comprehensive range of potential crops/trees. It will include detailed mapping of suitable production areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R7 400 000 (incl. leverage)
Expected term: 2009 - 2015

Water use efficiency of irrigated agricultural crops determined with satellite imagery
UKZN (Bioresources Engineering and Environmental Hydrology)
No. 2079

Advances in recent years in the use of remote sensing (RS) information now make it possible to assess crop water use, biomass and yield production (and WUE) spatially for each pixel (< 30 to 250 m) of a satellite image. For agricultural (field-scale) applications a number of models have been developed, including the Surface Energy Balance Algorithm for Land (SEBAL) model. Assessing the spatial WUE data over time can help farmers to detect, e.g., an uneven application of irrigation water (in a field or across a farm or irrigation scheme), a mismatch between irrigation water supply and that actually required (indicating over- or under-irrigation), potential seepage losses or drainage problems and other resources (e.g. fertiliser and energy) wastage. This project will build on research projects conducted in South Africa in recent years where the use of spatially-explicit data (from the SEBAL model) in irrigated agricultural water management has been evaluated. In South Africa, there is a need for information to be available operationally, so that WUE at field, farm and irrigation scheme level can be evaluated regularly, problems detected and addressed swiftly, crop WUE and other resource use (fertiliser, electricity, etc.) optimised, and water wastage minimised. This project will aim at conclusively confirming the degree of accuracy of the SEBAL model (when compared to traditional methods) for estimating ET and WUE of selected agricultural crops. This project should therefore pave the way for the operational near real-time application of RS data in agricultural water management. There will be collaboration with potential users of the data (researchers, farmers, irrigation advisors, water managers on irrigation schemes) and the project will continue to build capacity (students, extension officers, researchers) in generating and using this data.

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2011 - 2014

Investigating the possibility to improve water use efficiency and reduce canopy management inputs of wine grapes through deficit irrigation
ARC Infruitec-Nietvoorbij
No. 2080

At present, wine grape farmers are advised by viticulturists to follow certain canopy management practices, such as suckering, tucking in and topping of shoots. This is done to ensure that the grapes fall within a prescribed quality class. Under current economic circumstances, as well as with the rising cost of labour and fuel prices, these practices are becoming increasingly expensive to maintain, as farmers are not necessarily compensated for the additional expenses. Knowledge of how different canopy management practices at different deficit irrigation strategies will influence the combination of vegetative growth, production and wine quality is limited. A completed Winetech project investigated the effect of different deficit irrigation strategies on the water usage, production, growth, plant water potentials and overall wine quality, and crop factors were determined for a range of irrigations at different soil water depletion levels. The same canopy management was applied to the grapevines of all the treatments (two-spur winter pruning, suckering twice during spring and the tucking in of shoots into trellis wires). The cost of these different management practice inputs has not been investigated. In previous irrigation trials conducted on wine grapes, a blanket standard canopy management was done on all the treatments as the object of these trials was to investigate the effect of the different irrigation strategies on the grapevines' yield and wine quality. In previous canopy management research, the same irrigation volumes were applied to the various treatments while their canopies were manipulated. The effect of different canopy management inputs in combination with different irrigation strategies, and the water requirements of these different canopies, has thus not previously been investigated. Depending on the outcome of the trial, the results could be used as subroutines in future economic models to calculate the profitability of wine grape vineyards.

Estimated cost: R2 072 000
Expected term: 2011 - 2015

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact
University of Stellenbosch (Division of Aquaculture)
No. 1802

This project will investigate the feasibility and practical implications of using on-farm irrigation water storage dams for aquacultural fish production. A recently-completed WRC project (No. 1461) found that although this dual use of water is mostly beneficial, it can also impact on water quality. This is a follow-on project that will continue with monitoring the effects of aquaculture at a number of sites, follow-up on the environmental concerns (especially enrichment or eutrophication of dam water) and investigate management and other measures aimed at reducing the enriching effects associated with intensive cage aquaculture.

Estimated cost: R1 680 000
Expected term: 2008 - 2013

An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing
University of Pretoria (Department of Microbiology and Plant Pathology)
No. 1875

With decreasing water resource availability for agricultural purposes and increasing water pollution, contamination of food products may increase health risks. Poor health due to water and food contamination has negative impacts on the productivity of human resources in all sectors of the economy. This emphasises the importance of minimising food safety risks. Due to under-nutrition, consumption of fresh and raw fruit and vegetables is encouraged as a source of essential micro-nutrients. If the water and produce are not safe, or if there is a lack of effective food safety management, this benefit may be eliminated and the health of all people, but in particular the vulnerable poor people, will weaken. In addition, earning of foreign exchange is a key contribution of agriculture to the economy. Microbial contamination of food products for local and export markets will have negative impacts on trade relationships. Losing market access due to perceived high risks of contaminated produce could have severe constraining implications for future economic development. For food safety management, European and American models are currently applied. These are not necessarily appropriate for South Africa and consequently the risk may not be correctly assessed. In addition, CODEX standards are presently adopted and officials are not able to benchmark these with locally verified data. Therefore, this research project on microbial contamination of fruit and vegetables will enable the drafting of relevant national microbial standards which comply with international requirements. The knowledge obtained through the project will also contribute to effective management of water resources and food products to improve food safety. Better understanding of the nature and extent of the problem of microbial contamination of food, in the context of South Africa as a developing country, will support accurate health risk assessment and subsequent community health management.

Estimated cost: R6 219 200 (incl. leverage)
Expected term: 2009 - 2015

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services
ASSET Research
No. 1803

Large parts of the South African landscape, especially the former homelands, are heavily degraded and denuded due to, amongst other factors, historical over-population, mismanagement and exploitation of natural resources. While the country does have a limited history of restoring natural capital, i.e. rangelands and grassland catchments, woodlands and natural landscapes, few comprehensive analyses have been done to assess the ecological, hydrological and socio-economic impacts of rehabilitation across a range of contrasted sites and contexts. Very few investigations have been conducted to determine the tangible contributions restoration

has made and can make to rural landscapes and local economic development. This study will assess the ecological, hydrological and socio-economic impact of improving degraded landscapes across the country at a number of contrasted sites in an integrative and dynamic systems approach. This will be done using a carefully selected assemblage of parameters to study how restoration specifically improves water flow, water quality, land productivity and in some instances carbon sequestration as well as generally improving the agricultural potential of the land. In addition, the socio-economic benefits of restoring natural capital will be assessed by investigating the contribution to employment creation and income generation. The economic quantification of restoration is likely to provide critical data needed for the implementation of payment for environmental services. A model will be developed based on information gathered by this study to assist in predicting the impact of future restoration projects on complex and dynamic socio-economic and ecological rural landscapes. This model will be used to consider the most effective and best ways to embark on future restoration projects. This decision support tool will be very valuable to national programmes and projects such as Working for Water, Working for Wetlands, Working for Woodlands and the land-care project.

Estimated cost: R3 450 000 (incl. leverage)
Expected term: 2008 - 2013

Water use and economic value of the biomass of indigenous trees under natural and plantation conditions
CSIR Natural Resources and the Environment
No. 1876

Specific findings, recommendations and gaps in knowledge regarding the water use efficiency (WUE) and economic potential of indigenous tree systems were identified in a previous WRC project (K5/1462) which was finalised in March 2008. These included the need for improved understanding of the WUE of a wider selection of indigenous tree species growing under a range of bio-climatic conditions in South Africa. This information is needed to explore the possibility of expanding and growing the local forestry industry using indigenous tree species. Potential benefits of this expansion include the expected lower water use rates of indigenous species, and the high economic value of biomass products. Furthermore, it is important to place the water use of exotic commercial plantations in perspective, through comparisons with indigenous tree-production systems. There is also a need to establish a baseline water use by indigenous trees under natural conditions to facilitate the evaluation of likely water resource changes associated with a change in land use. Improved knowledge in these aspects will contribute to improving or enhancing rural livelihoods through the use of indigenous tree-production systems. In addition, possibilities exist to provide alternative wood-production systems to replace alien invasive plants, as the process of alien plant eradication continues. Ultimately, the research output should enable formulation of recommendations regarding the use of indigenous natural and plantation tree systems, with emphasis on WUE, site-species matching and economic viability to support sustainable rural development.

Estimated cost: R6 799 100 (incl. leverage)
Expected term: 2009 - 2015

Rehabilitation of alien-invaded riparian zones and catchments using indigenous trees: An assessment of indigenous tree water use
University of Pretoria (Plant Production and Soil Science)
No. 2081

Much of the tree water use research is based on forest hydrology and has focused on exotic tree species and their impacts on streamflow. In order to support the Government's rural tree programmes, there is a need to expand current research to include the water use of indigenous trees used in forest expansion, the rehabilitation of degraded lands and the restoration of riparian zones. One of the biggest problems with current rehabilitation programmes is that exotic species (e.g. vetiver grass) are used to restore the ecosystem services (e.g. water production and reduced soil erosion). However this ignores the importance of ecosystem structure and functioning (e.g. biodiversity). Research and policy support in South Africa is required to promote and scale-up indigenous tree planting and growing initiatives in degraded areas and riparian zones. The impact of expanding the use of indigenous trees to catchment hydrology is of critical importance in a water-scarce country. It is therefore important to understand the plant water use (transpirational changes) brought about by introducing indigenous trees into degraded landscapes and alien-cleared riparian zones. There is a widespread belief in South Africa that indigenous tree species, in contrast to the exotic trees, are water-efficient and should be planted more widely in land restoration programmes. This is based on observations that indigenous trees are generally slow growing, and that growth and water-use are broadly linked. However, tree water use is technically difficult and expensive to measure, and so there is scant evidence of low water-use by indigenous trees. This is even more so for pioneer tree species more suited to the rehabilitation of degraded lands and those found re-colonising riparian zones previously invaded with exotic trees (e.g. wattle). This study will therefore focus on determining the water use of potential indigenous, pioneer tree species suitable for rehabilitation programmes.

Estimated cost: R4 900 000
Expected term: 2011 - 2016

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 fuelwood. 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 characterized 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: R4 728 500 (incl. leverage)
Expected term: 2007 - 2013

Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province
Tshwane University of Technology; ARC (Institute for Agricultural Engineering)
No. 1804

Livelihoods of plot-holder homesteads on small-scale canal irrigation schemes in South Africa are diverse and dynamic and the importance of irrigated farming in the livelihood portfolio of these homesteads also varies. Typically, the objectives of plot-holders on small-scale irrigation schemes range from production of food solely for own consumption to fully market-oriented production. While market-oriented farmers seek to expand the scale of their enterprise, subsistence farmers (food producers for own consumption) tend to have excess land. Most of the smallholder farmers on irrigation schemes require technical improvements to the prevailing production systems to enhance the financial viability of plot enterprises and increase the efficiency of water and land use. Effective management of shared resources such as water is essential to all farmers on the irrigation schemes and is dependent on collective action. Despite the multi-faceted challenges facing smallholder irrigation schemes, very little research has been successfully conducted on integrated production systems on these schemes. At this stage these schemes are also not included in RESIS of Limpopo Province, except if farmers are prepared to switch to sprinkler irrigation. Changing to sprinkler irrigation will not necessarily increase water-use efficiency, particularly if it is done without participation by farmers. This project seeks to enhance plot-holder scheme productivity and to strengthen collective action by improving the availability of irrigation water to farmers. It will seek to enhance the establishment of robust community-based institutional systems that reduce uncertainty and risk in land-exchange contracts. It will also endeavour to integrate crop and animal production in order to contribute substantially to local resource use, value-adding and market access on smallholder irrigation schemes. In order to achieve these objectives, the project will adopt a participatory learning and action approach to collectively analyse the existing behavioural and communication patterns. It will employ both plot and field experiments in an effort to encourage the efficient use of water and improve plot-holder productivity. The final output of this project will be a comprehensive report that documents the holistic approach followed in addressing the challenges facing smallholder irrigation farmers and lessons learnt as well as practical crop and animal production manuals for smallholder farmers and their advisers. These outputs will contribute to national programmes of high priority that address issues of poverty alleviation and food security.

Estimated cost: R1 890 000
Expected term: 2008 - 2013

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods
Rhodes University (Department of Ichthyology and Fisheries Science)
No. 1957

In South Africa the potential of inland fisheries, which exists in the form of hundreds of water impoundments or storage dams throughout the country, is largely underdeveloped and underutilised. With exception of traditional practices in e.g. specific regions of KwaZulu-Natal and Limpopo Province, there is no culture of fish consumption in rural areas, despite the fact that fish is one of the best sources of protein. Due to the decline of production of marine fish stocks (which has been caused by overfishing) and a higher demand for fish, the price of fish is increasing. With increase in demand, the development and use of water resources in storage dams for inland fisheries have the potential to contribute to uplifting rural economic activity. There is a need for government interventions to formulate policies and strategies that support inland fisheries. These inland fisheries encompass community-managed subsistence fishery, commercial fishery and recreational fishery. The links between hatcheries, aquaculture and inland fisheries, such as culture-based fisheries, and the stocking of small farm dams and large storage dams, also needs to be explored. Inland fisheries can thereby create a fairly large support base for job creation, skills development and poverty reduction at a local level. Sustainable use of water resources with inland fisheries requires appropriate institutional arrangements, organisational structures and governance systems, for the application of technologies, management of water resources and service delivery to be successful. In this baseline and scoping study the current situation regarding water use for inland fisheries will be documented. Contributions will be made to formulate strategies for future development. The gaps in knowledge and priorities for further research will be identified.

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2010 - 2014

Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, Limpopo Province
University of KwaZulu-Natal (Agriculture Sciences and Agribusiness)
No. 2082

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water use security and lack of knowledge to achieve food security. Lack of water and land use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the abovementioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household

level that impact on the empowerment of women and attainment of sustainable food production. It includes better understanding of institutional and organisational impediments affecting the decision making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc., on the one hand, and the observed under-utilised land and water resources at local level in rural areas on the other. Finally more empirical information must be documented on the existing and required knowledge, as well as skills, for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost: R3 000 000
Expected term: 2011 - 2015

Empowerment of women through water use security, land use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, the Eastern Cape Province
Umhlaba Consulting Group (Pty) Ltd
No. 2083

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water use security and lack of knowledge to achieve food security. Lack of water and land use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the above-mentioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household level that impact on the empowerment of women and attainment of sustainable food production. It includes better understanding of institutional and organisational impediments affecting the decision making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc. on the one side and the observed under-utilised land and water resources at local level in rural areas on the other. Finally, more empirical information must be documented on the existing and required knowledge as well as skills for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost: R3 000 000
Expected term: 2011 - 2015

Empowerment of woman in rural areas through water use security and agricultural skills training for gender equity and poverty reduction in KwaZulu-Natal and North West Province
North West University (Department of Agricultural Economics and Extension)
No. 2176

In rural areas land is available, and the high unemployment rates, generally ranging from 30 to 40%, suggest the availability of labour to practise agriculture. Whilst financial and infrastructure support for resource-poor farmers in rain-fed and irrigated agriculture is

clearly required, investment in social and human capital, i.e., trust among people, clear property rights, the rule of law, education and skills development are equally important. Secure water use entitlements and land tenure are essential to provide incentives for enabling the poor to increase productivity of natural resources. A report to guide policy in Eastern and Southern Africa published by IMAWESA, recognized that meeting the agricultural water management challenge requires five key actions. These include providing secure rights to land and water and developing human capacity. A key feature for sustainable rural productivity will clearly be to develop capacity of the principal users of the land who are women. It has been reported that women constitute 70% of the agricultural labour force and are the main food producers for rural households in South Africa. However, there is sufficient evidence to suggest that poor rural women are considerably more disadvantaged than poor rural men because of an explicit gender bias in land allocation, access to credit, access to rural organisations, marketing channels and agricultural services in general. Women living in traditional rural areas form part of the most economically and socially disempowered groups in South Africa. This project focuses on the skills and training needed by rural women in order to sufficiently equip them to address the challenges of food insecurity and poverty. Although reports on agricultural training and skills development are widely available and have been well documented, very few, if any, are specifically tailored to meet the skills and training requirements of women in rural areas within cultural and traditional realities. The project will identify skills required by women in agriculture (farming and non-farming activities within the food value chain) but will not develop training guidelines.

Estimated cost: R3 000 000
Expected term: 2012 - 2016

Programme 2: Integrated water management for profitable farming systems

Analysis of food-value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy
University of KwaZulu-Natal (Institute of Natural Resources)
No. 1879

The inclusion of subsistence and emerging farmers in the mainstream of the economy is a nationally identified priority. Structural and cyclical obstacles must be overcome to accomplish this. These are mainly the dualistic nature of the agricultural economy and the recent occurrence of food shortages with high input costs. Although expectations are high for subsistence farmers to enter the market, experience shows that technical and business skills are required to obtain access to assets in agriculture by entering food-value chains. With high poverty levels and increasing unemployment, there is also a need to ensure growth with equity and therefore impacting on a wider group of people to promote rural economic development. Achieving this is a real possibility, since on the demand side there are different value chains, with consumers demanding food in different marketing outlets. On the supply side there are a large number of rural inhabitants, which includes groups who can be broadly categorised as subsistence, emerging and commercial farmers, who can potentially respond and enter any one or a combination of these value chains. The productive use of water in the value chain for both rain-fed and irrigated food production is of particular importance. The project will investigate factors such as needs and aspirations, technical capabilities, risks of crop production, food price expectations, water use security and incentives to increase water productivity which influence the decision of what value chain to enter and the degree of success

obtained. The report will highlight innovative ways to promote integration of subsistence, emerging and commercial farming in food-value chains for crop and animal products with use of rain- and irrigation water.

Estimated cost: R2 999 989
Expected term: 2009 - 2014

Investigation of water conservation in food value chains by beneficiaries of water allocation reform and land reform programmes in South Africa
CSIR (Water Resources Governance System)
No. 1958

The Water Allocation Reform Strategy of the Department of Water Affairs and Forestry (2008) states that by 2014, 30% of allocable water should be to the benefit of Black people. By 2024 the target is 60%, of which half should be under control of black women. Indications are, however, that so far very few water use entitlements have been awarded and/or taken up by individuals or groups of black emerging farmers. Evidence is also increasing that most water allocation reform and land reform projects are not leading to sustainable development. For establishment of commercially-oriented black farmers, the support services need to be substantially improved. These include access to finance and markets, better local organisation, improved management training and provision of extension services. Food value chain analysis is an appropriate basis for determining the requirements for integrating subsistence, emerging and commercial farming enterprises. There are different approaches for this analysis and in practice value chains vary in complexity. Food value chains essentially are the different stages for the production, marketing and distribution of goods and services. Important participants are value chain players (e.g. farmers, processers, retailers); influencers (e.g. regulators of food safety and trade); and supporters (e.g. providers of information and training). Within the embeddedness of a particular set of societal norms, the structure, conduct and performance of value chains can be analysed in combination with institutional arrangements, governance systems and resource allocation. In the South African context of water allocation reform, this approach should be applied and tested. The research input will show how black emerging and white commercial farmers can be integrated and productivity of water use can be increased through value adding in the food chain. Recommendations will be made to give support and direction to successful implementation of the Water Allocation Reform Strategy and enable meeting of the set targets.

Estimated cost: R3 000 000
Expected term: 2010 - 2014

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Methodology to monitor the status of water logging and salt-affected soils on selected irrigation schemes in South Africa
ARC (Institute for Soil, Climate and Water)
No. 1880

Major capital investments have been made in irrigated areas of South Africa. Declining productivity due to salinisation will have an impact on individual farms and the sustainability of food production is potentially threatened. Therefore, it is important to monitor degradation and plan rehabilitation at scheme level. Since the late 1980s no national effort has been

made to quantify the extent of water logging and salt accumulation across irrigation schemes. Indications are that water quality is declining and these problems are actually escalating. In order to identify soils for drainage and reclamation, the extent of water logging and salt accumulation has to be determined. National monitoring of water logging and salt accumulation is a high priority but currently no verified methodology is available to undertake this task. Data of soil conditions for different irrigation schemes is located at different organisations and the ARC-ISCW needs to be supported to act as custodian of baseline soils data. The GIS database and mapping is a new tool that is available for national application with the Agricultural Information System (AGIS). The general aim of this project is to develop and test a methodological approach for identification, classification and monitoring the extent and degree of water logging and salt accumulation at scheme, farm and field level. Guidelines will be produced for application at national scale which will ensure sustainable utilisation of soil and water for irrigation.

Estimated cost: R3 693 800
Expected term: 2009 - 2015

Development of technical and financial norms and standards for drainage of irrigated lands
ARC (Institute of Agricultural Engineering)
No. 2026

The extent and severity of drainage problems on irrigation schemes in South Africa is clear from the fact that an estimated 242 000 ha is affected by rising water tables and salinisation. These problems appear to be expanding and indications are also that costs of drainage have increased quite significantly. Apart from isolated projects which were undertaken for specific reasons, no comprehensive research on drainage has been done in South Africa over the past 25 years. Existing norms and standards have been adjusted over the years by means of ad hoc studies. There is evidently a need to revise and publish up-to-date norms and standards. New ways of managing drainage should be introduced instead of having only a narrow focus on the presently-known solutions. Irrigation, surface run-off and sub-surface drainage are all related and need to be managed as a whole. It is essential to distinguish between requirements and standards for design, installation, operation and maintenance of drainage. The internationally available research results and modelling approaches will be assessed and evaluated for applicability in South Africa. The demand for design and installation of drainage in the field by far exceeds the available capacity. Timing is critical because only a very small group of experts is still active in the field and there is an urgent need to train new practitioners. This report will form the basis for training at tertiary level and for providing guidance to practitioners. The research output will form the basis of informing public policy formulation and strategies for implementing drainage systems on irrigation schemes.

Estimated cost: R4 000 000
Expected term: 2010 - 2015

Programme 2: Impact assessment and environmental management of agricultural production

Impact of wastewater irrigation by wineries on soils, crop growth and product quality
ARC (Infruitec, Nietvoorbij)
No. 1881

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation

of agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well known and their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

Estimated cost: R3 500 000
Expected term: 2009 - 2014

Adaptive interventions in agriculture to reduce vulnerability of different farming systems to climate change in South Africa
University of Cape Town (Climate Systems Analysis Group)
No. 1882

South Africa has a high risk agro-hydrological environment which is likely to be exacerbated under conditions of climate change. It is widely recognised that ongoing changes in climatic conditions will generally have an adverse effect on, amongst others, agricultural production, biodiversity and water resources. Agriculture is a key sector in the economy with regard to rural livelihoods and food security and it is therefore vital to proactively access potential impacts of climate change on this sector. The National Disaster Management Framework of South Africa, a legal instrument specified by the Disaster Management Act, No 57 of 2002 recognises a diversity of risks and disasters that occur in Southern Africa, and gives priority to developmental measures that reduce vulnerability of disaster-prone areas, communities and households. In addition, the National Climate Change Response Strategy for South Africa, compiled in 2004, aims to address issues identified as priorities for dealing with climate change in each sector in the country. These documents informed the recently completed Climate Change Sector Plan for Agriculture compiled by the Department of Agriculture. The plan seeks to address institutional arrangements, vulnerability assessments, adaptation and mitigation as well as response and recovery of the agricultural sector as a result of climate change. Research related to vulnerability and adaptation is identified in the plan as a priority. There is a lack of integrated knowledge regarding the vulnerability of agriculture in terms of climate change and water availability. The project aims to investigate the impact of projected climate change on agriculture; assess the vulnerability of crops, rangelands

and farming households and enterprises; identify and suggest appropriate adaptive techniques and practices in selected catchments and farming areas. The report will provide an assessment of the vulnerability of different farming systems to climate change. It will evaluate alternative adaptation practices and techniques (indigenous and science-based knowledge) and if necessary develop and test innovative, appropriate and sustainable interventions, including internal management measures and external policy measures.

Estimated cost: R4 300 000 (incl. leverage)
Expected term: 2009 - 2016

Improving the livestock carrying capacity with rainwater harvesting and conservation on grasslands for extensive and/or intensive livestock production and biogas generation from manure in rural areas of South Africa
University of KwaZulu-Natal (Department of Grassland Science)
No. 1955

The majority of households in communal areas are dependent on resources from the local woodlands, grasslands and livestock production. Livestock are a potential asset to rural households because of the opportunities presented for participation in the rural economy. It has been shown that households are eager to keep livestock for the multiple benefits they provide, rather than for exclusively social status. One potential benefit is livestock as a source of manure for biogas production. Biogas technology, in its simplest form, involves the use of digesters that are vessels in which animal waste and other biodegradables are broken down (digested) by bacteria in the absence of oxygen. In particular livestock manure must be collected, transported and stored for the biogas digester. Therefore it is important to consider how livestock will be managed with reference to rotational grazing on the commons, keeping livestock in a kraal overnight near the village and utilising manure from the kraal for biogas digesters at household or village scale. These household or village scale biogas digesters require access to water, therefore rainwater harvesting tanks will need to be constructed. Biogas generation as an energy source for cooking, heating, cooling and lighting can play an important role in improving the quality of life for rural households. It is a single intervention that directly addresses energy insecurity, and indirectly through liquid fertiliser also food security, at the household garden level and thereby reduces vulnerability of the poor. By linking biogas generation to manure management and rainwater harvesting, this research report will make an innovative contribution and fill a major knowledge gap.

Estimated cost: R5 000 000
Expected term: 2010 - 2015

Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health
CSIR (Natural Resources and the Environment)
No. 1956

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine

disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825 (Incl. leverage)
Expected term: 2010 - 2015

Insights into indigenous coping strategies to drought for drought adaptation in agriculture: The Southern Cape scenario
Cape Peninsula University of Technology
(Centre for Water and Sanitation Research)
No. 2084

Drought is a normal, recurrent feature of South African climate. In the past, droughts have resulted in significant economic, social and environmental impacts on the country. South Africa will continue to experience droughts and the likelihood of serious drought is greater with climate change. In the Western Cape Province, for example, climate change projections indicate that the province can expect less rainfall, particularly to the eastern parts of the province. Thus the future climate change projections mentioned indicate that droughts will become a more regular phenomenon. The Southern Cape is the area most vulnerable to such extreme events and therefore the area of investigation. To develop drought preparedness strategies it is critical to capture local experiences. There have been limited studies capturing indigenous local knowledge of the impacts and experiences of past and current droughts in South Africa. Completed studies recommend three groups of drought mitigation measures –supply-orientated, demand-orientated and minimisation of impacts and losses. However, these coping strategies and mitigation measures are not concerned with local practices, and certainly do not incorporate indigenous knowledge and practice. In any case, these concern drought experiences of two to three decades ago. It is therefore critical that the experience of the current drought in the Southern Cape be captured to adequately prepare and mitigate against future anticipated droughts in the region. The research is intended to capture and assess local coping strategies and experiences of a current drought within the agricultural sector to inform preparedness planning for future droughts. In this respect the research would contribute to an indigenous knowledge base for informing mitigation and preparedness planning in both disaster risk management and climate change adaptation for the agricultural sector.

Estimated cost: R712 000 (incl. leverage)
Expected term: 2011 - 2014

NEW PROJECTS

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

Nutritional water productivity of indigenous food crops
ARC (Vegetable and Ornamental Plant Institute)
No. 2171

Many indigenous vegetables (underutilized crops in particular) have high nutritional levels of micro-nutrients and could significantly contribute to nutritional security if eaten as part of the daily diet. A WRC project on nutritional value and water use of eight indigenous vegetables showed that 100 g leafy indigenous food crops (morogo) contain sufficient beta-carotene to supply more than 80% of the recommended daily allowance (RDA) of 4-8 year olds, and more than 40% of the RDA for 19-50 year olds. The eight indigenous food crops studied for their nutritional value were amaranth, cowpea, chinese cabbage, nightshade, spider flower, jew's mallow, watermelon and pumpkin leaves. Despite the importance of these vegetables in combating malnutrition and poverty, they are still poorly understood by the South African scientific community. In the abovementioned project, one of the research gaps identified was whether crop nutritional value is closely interlinked to water and nutrients, especially nitrogen (N), potassium (K) and phosphorus (P). This new project will explore the nutritional water productivity of four indigenous food crops, which have the potential to broaden the food basket. The crops are jute mallow, orange-fleshed sweet potatoes, nightshade (or *Amaranthus*) and *Cleome*. These crops are selected based on their popularity, nutritional quality and potential for small-scale and commercial production. The above questions will be investigated through field experiments linked to the ongoing Department of Science and Technology (DST) funded projects at the ARC-Roodeplaat VOPI, particularly the commercial production and breeding programmes of these indigenous food crops. Considering the importance of indigenous vegetables to combat malnutrition and broaden the food base in rural South Africa, the DST has funded ARC with over five million rand per year for the next three years. Rural based universities are targeted for this trial work as a major access point to the rural communities to introduce the technology solution developed at the ARC.

Estimated cost: R1 950 000
Expected term: 2012 - 2016

Current rain-fed and irrigated production of food crops and its potential to meet year-round nutritional requirements of rural poor people in North West, Limpopo, KwaZulu-Natal and Eastern Cape Provinces
University of Pretoria (Institute for Food, Nutrition and Well-being)
No. 2172

Renewed attention must be given to agriculture, nutrition and health in adjusting research agendas, and strategies must be directed at early childhood nutrition, particularly of poor households. More research is needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices. The on-going WRC scoping study (WRC Project No. K5/1954//4) entitled 'A baseline and scoping study on water use and nutrient content of crop and animal food products for improved household

food security' identified insufficient data on food intake of poor households in rural areas of South Africa. The study also found that very little information is available on the sources of foods consumed by rural households. This means that, overall, insufficient data are available to make generalisations about the 'basket' of foods and the source of foods of the rural poor in this country, and consequently it is difficult to develop appropriate programmes that will improve the nutritional health of rural communities. Although dietary studies indicate that rural poor people meet very little if any of their nutritional requirements through own food production, this is contradicted by case study evidence from an agricultural perspective. It is therefore necessary to undertake empirical research on food production and intake by poor households. Opportunities exist that some of the foods in a balanced diet can be produced in gardens or field plots, which are currently underutilised. The provinces of North West, Limpopo, KwaZulu-Natal and Eastern Cape have been prioritised because this is where the majority of rural poor people live and produce crops under rain-fed and irrigated conditions, and potential exists to enhance production. It is important to identify the food crops for detailed follow-on research of water use and nutritional productivity for the purpose of reducing under-nourishment and increasing household food security.

Estimated cost: R3 650 000 (incl. leverage)
Expected term: 2012 - 2016

Water use and crop parameters of pastures for livestock grazing management
University of Pretoria (Department of Plant Production and Soil Science)
No. 2173

The focus of this project will be to integrate irrigation and nitrogen management in order to improve the efficiency of both inputs. In South Africa, returns generated from animal production enterprises make pastures one of the highest value crops produced under irrigation. It is estimated that the total area utilized for irrigated pasture production is approximately 16% of the total area under irrigation. The most common irrigated pastures are ryegrass, kikuyu and lucerne. Irrigated ryegrass and dryland kikuyu with supplemental irrigation are the primary sources of feed in the pasture-based dairy industry and these are mostly grown in the relatively higher rainfall areas. Therefore, in this project, the promising practice of temperate legume with tropical grass or temperate grass mixture and the most commonly practised grazing mixture of kikuyu/ryegrass will be researched. Lucerne is regarded as the most important pasture legume produced in the drier parts of South Africa for its high quality roughage (hay). This roughage is extensively used in many animal production systems, including feedlots, dairy systems, the animal feed industry and the wildlife industry. The studies to be conducted under controlled environments and at representative research stations and commercial farms will aim to: 1) determine water use and irrigation requirements of most common farmers' practices including kikuyu/ryegrass, legume/ryegrass mixtures and lucerne; 2) evaluate irrigation systems (flood, sprinkler and sub-surface drip) for lucerne production; 3) conduct detailed physiological studies of lucerne as affected by different water stress treatments, and 4) parameterise, test and validate selected crop growth/pasture model(s). As end products, databases of irrigation requirements of kikuyu/ryegrass, clover/ryegrass mixtures and pure lucerne under different pasture management practices will be developed. Finally, The validity and practicality of irrigation tools developed will be assessed in conjunction with pasture-producing industries.

Estimated cost: R2 750 000
Expected term: 2012 - 2016

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Scoping study on different on-farm treatment options to reduce the high microbial contaminant loads of irrigation water to reduce the related food safety risk
University of Stellenbosch
(Department of Food Science)
No. 2174

There is an urgent need for research into possible on-farm treatment options to help reduce the high levels of microbial contamination in irrigation waters and thereby reduce the associated food safety risk to consumers. Of primary concern during such treatment is the reduction of pathogens in the irrigation water, and that the treatment process be financially feasible and technically appropriate and robust. Over the past few years it has been established that many of the South African rivers that are drawn from for agricultural irrigation purposes are carrying extraordinarily high pathogenic loads; some of the products irrigated by this water are minimally processed foodstuffs or products that are consumed raw. The WRC projects 'A quantitative investigation into the link between irrigation water quality and food safety' (K5/1773//4) and 'An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing' (K5/1875//4) have clearly demonstrated the extent of the problem in terms of geographic distribution and the high microbial loads in rivers used as irrigation water sources. Several risks have been identified when polluted water is used for crop irrigation. Risks can be short-term and range in seriousness, depending on the potential contact with humans, animals and the environment. No irrigation water contaminated by untreated or poorly-treated faecal waste is risk-free. The purpose of this scoping study is to explore alternative on-farm treatment options that can reduce this risk. Emphasis will be placed on technical and financial feasibility and determining the priorities and scope for further research.

Estimated cost: R2 250 000 (incl. leverage)
Expected term: 2012 - 2016

Evaluation of the risks associated with the use of rain-water, harvested from roof tops, for domestic use and homestead food gardens; and groundwater for domestic use and livestock watering
University of Pretoria (Department
Microbiology and Plant Pathology)
No. 2175

Harvesting rainwater from rooftops is an ecologically-friendly alternative approach to addressing the country's critical water shortages. Water collected in this manner can address domestic water shortage and provide irrigation water for home gardens. Prior to promoting rooftop water harvesting, it is essential to determine the potential level of microbiological and chemical risks associated with such water collection systems. Water collected in this manner is also commonly stored in large plastic containers using well-known brands such as Jo Jo. The ability of microorganisms to proliferate in such water storage systems has been well documented. The quality of such harvested and stored water is however, not well known. In general,

dust, bird droppings, chemical leachates from the roof material, adhesives and coatings, etc., may be washed down from the roofs after heavy rain storms with the result that this water will be collected in the storage water unit posing a potential risk for the consumer. Water quality may thus be compromised by the water collection approach. In addition, biofilms may develop in the storage unit and may further compromise the water quality. This is of particular importance since it is known that waterborne pathogens may survive, proliferate and shed into the waterways thereby contributing to the contamination risk. While the quality of groundwater varies significantly from one area to another, available research results (WRC Report 1175/1/06) to assess the risk of groundwater for use in domestic consumption as well as livestock watering has to be refined and updated. By understanding the risks associated with roof-top harvested rainwater and groundwater, improved usage of these valuable resources can be made. Through improved intervention strategies, guidelines and regulations, basic public health issues can be managed and exposure to contamination prevented.

Estimated cost: R2 750 000 (incl. leverage)
Expected term: 2012 - 2016

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Up-scaling of rainwater harvesting and conservation on communal crop- and rangeland through integrated crop and livestock production for increased water use productivity
Institute of Natural Resources (Department of Sustainable Agriculture and Food Security)
No. 2177

Sustainable crop-livestock systems can support the majority of poor members of rural communities. Rainwater harvesting techniques and practices in these systems have the potential to improve the livelihoods of these communities. Many rainwater harvesting techniques have been tested and are proven to be effective, but their successful application in rural areas for crop-livestock systems is limited. Clearly, correctly designed institutions and organisations are required to support the application of rainwater harvesting techniques by individuals and groups in communities. Conflict that often exists between livestock owners and crop farmers usually leads to low or no production. By clarifying the production potential and rules that determine access to resources, solutions can be found to resolve conflicts. Production systems should be geared towards optimising both crop and livestock production and exploiting the synergies between the two. By up-scaling from the homestead food garden to the croplands and rangelands, opportunities are created to increase production and move from subsistence to profitable levels of farming. In an uncertain environment, interventions such as rainwater harvesting for crop-livestock water use productivity can bring resilience to the system. However, the integrated functioning of the

crop- and rangeland system is not well understood. There is also a lack of knowledge of livestock water use productivity in rural areas since livestock have mainly been kept for cultural reasons, whilst demand for livestock products has increased. The challenge for research is therefore to adapt or develop technologies and practices which will improve land productivity whilst enabling water conservation in rain-fed agricultural production on dry-lands and rangelands. Participatory action research should be undertaken to demonstrate that higher crop and livestock water use productivity at lower risks is achievable.

Estimated cost: R2 750 000
Expected term: 2012 - 2016

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 2: Integrated water management for profitable farming systems

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Eastern Cape Province
University of Fort Hare (Department of Agricultural Economics and Extension)
No. 2178

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R1 950 000
Expected term: 2012 - 2016

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Limpopo Province
Umhlaba Consulting
No. 2179

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R1 950 000
Expected term: 2012 - 2016

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KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

DR INGA JACOBS | EXECUTIVE MANAGER

KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

SCOPE

This KSA supports the achievement of the organisational vision 'To be South Africa's premier steering and funding water research agency with a significant African and Global footprint'. The KSA assists with and coordinates the following strategic drives:

- New partnershipsImproved political profile
- Water technology development
- Stronger research and human capital development profile
- Budget and resource expansion
- International leadership

KSA 5 also addresses the management of water-centred knowledge (created via the support of the WRC as well as other sources) and leads the effective dissemination thereof.

The scope of this KSA includes:

- Facilitating and, where appropriate, formalising new partnerships
- Supporting the continuous improvement of the political profile of the WRC by enhancing the credibility and relevance of the WRC through strategic positioning and strengthening stakeholder relations
- Leading the up-scaling and demonstration of water technologies in partnership with the research KSAs and strategic partners

- Providing the instruments to track, measure and report on the impact of the WRC in research and human capital development
- Providing support to and, in some cases, leading initiatives aimed at increasing budget and resources
- Coordinating local and international dialogues led by the WRC
- Supporting knowledge creation by providing appropriate research management tools and logistic support
- Sharing and disseminating water-centred knowledge internally and externally
- Providing strategic research advice

The overall scope is further expanded in a number of thrusts:

THRUSTS AND PROGRAMMES

THRUST 1: RESEARCH – WATER-CENTRED KNOWLEDGE

Aim:

- To provide strategic research advice related to the water sector, R&D capacity, knowledge flow and ultimate impact

The WRC is mandated to lead and co-ordinate water research in South Africa. It is also tasked to promote effective knowledge transfer and enhance knowledge and capacity in the sector. It is therefore important that the WRC understands all of the elements driving the water knowledge cycle in South Africa.

This KSA focuses on researching various elements, drivers and trends affecting the dynamics of the water-centred knowledge cycle, from issues related to research capacity and overall funding of research by the sector to the effectiveness of research and its impact on policy and technology used by the sector. This functional area may also provide advice regarding sector needs and global trends, i.e., foresight and scenario studies.

Examples of research/studies to be carried out under the leadership of this functional area are:

- Assessment of the scope and extent of water research done in South Africa
- Analysis of research capacity, demographics, current and future needs
- Impact of research, including methodology for impact assessments
- Long-term scenario building
- Assessing knowledge uptake and dissemination and establishing new effective mechanisms

THRUST 2: TECHNOLOGY TRANSFER AND IP MANAGEMENT

Aims:

- To demonstrate technologies and solutions through scale-up and demonstration facilities
- To manage the WRC patent portfolio and intellectual property according to the WRC IP Policy

This thrust ensures that the WRC promotes the effective transfer of information and technology through up-scaling and demonstration. In the words of the Department of Science and Technology's 10-year innovation plan, it serves as an enabler to address the "innovation chasm" between research results and socioeconomic outcomes. The thrust also includes the management of intellectual property.

THRUST 3: STRATEGIC POSITIONING AND PARTNERSHIPS

Aims:

- To enhance the credibility and relevance of the WRC locally and globally
- To coordinate strategic local, continental and international partnerships and facilitate dialogues which position the WRC as a significant international player and a recognised asset to South Africa

This initiative has in the past been decentralised in the WRC. This caused, to an extent, individuals rather than the organisation to be recognised. This new thrust has been created to coordinate national, continental and global initiatives and to formalise strategic partnerships without compromising the individual efforts of our Research Managers and Executive Managers. It provides the golden thread for key selected dialogues and partnerships in which the WRC wants to play a major leading role.

Another major initiative is the establishment of the Water Knowledge and Capacity Advancement Programme (WaterKCAP), in partnership with the DWA. The aim of the WaterKCAP is to provide a dedicated programme of support that enables research supervisors to provide higher numbers of high-quality Doctorate and Masters level graduates in priority water-relevant disciplines.

The WRC also continues to establish strategic partnerships with large industry, local government as well as national government departments and their agencies.

Other initiatives addressed in this thrust are:

- Establishing and strengthening of relationships with government departments and a number of portfolio committees
  - » Establish and maintain relationships with the National Planning Commission, portfolio committees, and various departments including Department of Water Affairs, Department of Health, Department of Science and Technology, Department of Agriculture, Forestry and Fisheries, Department of Cooperative Governance and Traditional Affairs, Department of Human Settlements
  - » Provide interactive information sessions to the portfolio committees and respond to their knowledge requirements
- Supporting national, African and global initiatives
  - » Support national initiatives of key importance to the water and other related sectors where the WRC plays a significant role
  - » Support other KSA initiatives through providing support related to exhibitions, media briefings, events management, etc.

  - » Support African initiatives for building water science and technology in the continent (example: NEPAD)
  - » Establish and maintain bilateral relationships
  - » Support global initiatives and partnerships, for example, through:
  - » Linking to international associations such as the International Water Association, World Water Forum, etc.
  - » Linking with the global research community through *Water SA*
- Prepare positioning material such as the WRC Annual Report, strategic messages, ministerial and policy briefs

THRUST 4: PUBLIC RELATIONS AND COMMUNICATIONS

Aims:

- To effectively share and disseminate relevant knowledge in the water sector and within the WRC and to develop knowledge-sharing mechanisms/ instruments to support the objectives of the WRC
- To build and maintain relationships with stakeholders
- To market the WRC effectively

This thrust complements the objectives of Thrust 3 utilising public relations, marketing and communication mechanisms. The KSA ensures that the WRC leads and participates in knowledge-sharing and knowledge-dissemination activities (e.g. workshops, exhibitions). It strengthens the WRC's ability to exchange information and data on developments around water management issues. It also oversees the flow of water-centred knowledge to and from the WRC by improving access to external information and water-centred knowledge, and acting as a resource centre to meet the information requirements of the WRC and the water sector in general. It includes:

- Driving the implementation of the WRC communication strategy
  - » Improving knowledge uptake with the aim to increase implementation
  - » Enhancing sector involvement in the WRC research processes
  - » Strengthening awareness of the mandate and role of the WRC in the South African water sector
- Establishing working relationships with industry, decision makers and key stakeholders
  - » Strengthening relationships through formal memoranda of understanding
  - » Providing knowledge in a format that is fit-for-use
  - » Delivering multimedia presentations to inform various target groups about the WRC and its accomplishments

- Supporting water-related youth and learner awareness programmes
- Knowledge sharing (external)
  - » Preparing media briefings, media conferences and networking events in order to create and sustain an awareness and appreciation among the media of the WRC's position of leadership within the water sector
  - » Developing and maintaining an Electronic Water Knowledge Hub for easy access to all WRC publications and resources
  - » Developing mechanisms for effective knowledge sharing and information transfer
  - » Exhibiting at high-profile, water-centred conferences nationally and, if necessary, internationally
- Knowledge sharing (internal)
  - » Organising knowledge-sharing events such as internal open days, guest lectures and regular research managers' meetings
- Enhancing the effectiveness of knowledge dissemination
- Supporting the research community
  - » Improving the relationship and interaction with the research community (during and beyond the project)
- Promoting the WRC at carefully selected opportunities
  - » Contributing to and/or advertising in selected media or periodicals to coincide with events of special significance for water, e.g. Water Week
  - » Engaging with the youth through science festivals, games and competitions to serve the dual purpose of positioning the WRC and stimulating interest in water-centred science, engineering and technology

THRUST 5: BUSINESS SYSTEMS MANAGEMENT

Aim: To coordinate the research funding cycle and provide effective tools, systems and procedures to support the core business of the WRC.

This KSA provides support to the 'engine room' of the WRC, i.e., the four key strategic areas mandated to coordinate and fund water research. It supports the management of research projects, enhances innovation and provides the tools and processes for protecting technological developments. It also links the financial processes with the technical fund management. This includes research management:

- Coordinate the annual funding cycle
- Provide the logistics required for the flow of research-related information into and out of the WRC
- Increasing the user-friendliness of the WRC Fund Management System (FMS) for both external and internal users

- Advance the linkage between financial and technical management of research projects
- Provide support to the research KSAs with regard to proposal cycle and project management on FMS
- Develop the FMS as a management information tool

THRUST 6: PRODUCTION AND KNOWLEDGE PACKAGING

Aims:

- To provide an effective printing and distribution service
- To package water-centred knowledge for different users

This KSA manages the production of WRC-funded research reports, technology transfer reports, *the Water Wheel, Water SA*, brochures and briefs. It includes:

- Printing and distribution
  - » Manage the quality-control process of WRC technical and technology transfer final reports
  - » Manage the process of layout and printing of the WRC reports and other publications
  - » Manage the effective distribution of research reports
  - » Manage effective report distribution facilities (manual and electronic)
- Knowledge packaging
  - » Develop and maintain innovative ways to share and disseminate WRC products, e.g. brochures, project briefing notes, Knowledge Review, media briefings.
  - » Support KSAs 1 to 4 with the production of technology transfer documents
- Promote the public understanding of science
  - » Produce and publish *the Water Wheel*
  - » Produce and publish special publications such as books and learning material
- Ensure that scientific knowledge is globally recognised and exchanged
  - » Manage the production and publication of *Water SA*

CORE STRATEGY

Strategic context

Globally, the scientific community is in agreement that knowledge use and uptake is challenging. The path from research to policy formulation is no longer a causal linear process where "research results in a product which is passed from the researcher to the policy maker" (Whitty, 2008). Policy formulation is a complex interaction of actors and includes several advocacy coalitions and networks. Similarly to other science councils and research organisations in the country, the WRC has to try to narrow the institutional gap between

policy-makers and the scientific research community by improving collaboration and strengthening partnerships.

In the South African water sector, the challenge is compounded by the constant change in the institutional and political environment. The organisations tasked with implementing legal and policy frameworks are constantly faced with a change in leadership, institutional changes and instability, high staff turnover, declining institutional memory and a highly-regulated environment which hinders the testing of developing concepts and technologies.

However, the recent outcome-based strategic approach developed by the South African Government provides a conducive environment for knowledge uptake as the sector gears itself to improve the impact of its efforts. This KSA will support the research KSAs in clearly communicating the link between research outputs and how these can assist Government in achieving the desired outputs. This KSA also coordinates the local and international dialogues aimed at firmly positioning the WRC in carefully selected themes such as adaptation to climate change.

Sector threats

The South African water sector faces challenges that could threaten the sustainability of its water resources. The dominant challenges to the country being able to sustainably supply water to meet its development goals in the future include issues related to water availability, climate change, infrastructure, human resources, compliance and enforcement, raw water quality, financial support and water pricing (Water for Growth and Development Framework, Version 7). Challenges in terms of a knowledgeable, productive water sector include:

- Functioning and pursuing continuous development in a resource-constrained environment
- The desperate and urgent need for solutions in the sector
- Working in a complex and multidisciplinary environment and often across institutions and disciplines
- Human resource capacity in the public sector – often qualified but less experienced people need to acquire a level of competence in a short period of time without the luxury of continuous mentorship
- Limited research capacity in certain of the water-related research areas and reduced ability to deliver on research contracts
- Shortage of South African students studying towards a higher degree in water-related disciplines – a balance is required between the need to continue research (creating knowledge) to ensure a sustainable water sector and the need to build capacity to export to other African states
- Relevance of the WRC; ability to provide South Africa with the knowledge required in the right format to improve service delivery and policy formulation

Relevance and impact

The relevance of the WRC depends in part on the organisation's ability to be the preferred supplier of knowledge to the sector. The absorptive capacity for knowledge generated by WRC-funded research is dependent on the manner in which it is packaged, understanding the complexity of the sector as well as the image of the WRC. The WRC, through this KSA, has started to place more emphasis on understanding and enabling knowledge uptake rather than focusing purely on knowledge dissemination.

KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

Van Ryneveld and Sproule (2009) defined knowledge uptake as "the ***active*** acquisition of disseminated information, the ***comprehension*** of the information and the ability of practitioners to ***apply*** the information in the field". While the WRC continues to generate water-related knowledge-based products which contribute to addressing the knowledge gaps in the water sector, it also seeks to understand the mechanisms of knowledge uptake.

The role of KSA 5 is therefore important for the continued relevance of the WRC and for the sustainability of a knowledge-based water sector. The emphasis has now moved to better understanding knowledge flow and developing and applying methodologies to enhance the uptake and application of the water-related knowledge generated by the WRC to solve the water challenges that South Africa faces. KSA 5 therefore aims to lead a consultative knowledge flows programme to create a better understanding of what the knowledge uptake drivers are.

It also strives to assist the research KSAs to enhance and encourage sector involvement from the early stages of appropriate research projects/programmes to:

- Improve knowledge sharing with the aim to increase implementation
- Enhance sector involvement in the WRC research processes

This KSA continues to support the organisation with knowledge creation and sharing through:

- Supporting research management and providing logistic support
- Developing effective internal and external knowledge sharing and dissemination mechanisms/instruments
- Enhancing the credibility and relevance of the WRC, locally, in the rest of the African continent, and globally
- Ensuring the appropriate management of intellectual property
- Supporting the WRC with advice on research contract matters

KEY STAKEHOLDERS

KSA 5 has both internal and external stakeholders. Internal stakeholders include the WRC Executive team and the CEO, who require services such as management reports and coordination of partnerships, agreements and international dialogues, as well as research managers and other staff of the WRC, who require coordination of the annual research cycle, operation of the fund management system (FMS), support related to intellectual property management and contract management, efficient layout, printing and publication stock control, and a dynamic interface with the local and global water sector (events, publications, media, etc.)

The WRC loosely defines its external stakeholders as:

- **Research community:** This includes the researchers working on WRC projects, the reference groups, peer reviewers as well as the primary users of the WRC outputs – technical users which include students, lecturers, consultants, other researchers, etc.
- **Decision makers:** These include managers and policy makers that use information to lead them to the selection of a course of action among several alternatives

- **Sectoral users:** These include all stakeholders that require new processes, solutions and technologies, e.g. local government, industrial and mining sector, agricultural sector, etc.
- **Strategic partners:** These are enablers and the relationship is mutually beneficial
- **Interest groups:** This includes the media, non-government organisations, general public, schools, etc.

An individual can dynamically move between these stakeholder groupings; for example, a DWA official could require knowledge which effectively informs policy (decision maker), and a while later use WRC research to solve a technical problem (sectoral user) while serving on several WRC reference groups (research community). The ideal is to understand the needs of a stakeholder depending on which role they play at a particular time.

Through regular stakeholder engagement and the stakeholder survey completed in 2010, the needs of the stakeholder groups can be summarised as follows:

Research community

The research community require an effective institution that serves as a catalyst and a knowledge hub to ensure the constant generation of knowledge. Effectiveness, transparency and inclusivity in the WRC processes are important to the research community.

Decision makers

Decision makers need packaged solutions and need to trust the information (credibility). They always need the solutions 'now'. This group cannot wait for long-term research to be completed and need to make decisions based on the best available knowledge. The WRC needs to be ready to supply the available knowledge and advise on the shortcomings to enable the decision maker to make an informed choice. For this stakeholder group, it is important to communicate the mandate and role of the WRC in the South African water sector as well as the role of the sectoral users as intermediaries. Their needs are complex and it is important to establish a trusting relationship in order to serve this group effectively.

Sectoral users

Sectoral users are primary knowledge users and partners who also play an important role in formulating new knowledge needs. They need to be part of the WRC processes and projects, and require easy access to WRC research products.

Strategic partners

Strategic partners require regular interaction, a clear understanding of the objectives of the partnership as well as the benefits of the relationship. Strategic partners include national government departments (in particular DWA and DST), enablers such as the Technology Innovation Agency and industry, as well as international strategic partners such as the IWA and the World Water Council.

Interest groups

Interest groups require accurate, credible, scientifically-proven information packaged in a manner that is easily understood.

Other stakeholders

This group includes local knowledge partners such WISA and SAICE. These organisations require water-centred knowledge, and the WRC can improve its

knowledge dissemination by creating appropriate links with them, thus making water-related documents, data and knowledge more accessible to internal and external users.

Other stakeholders also include continental and global stakeholders who work in collaboration with the WRC, and in some cases formal agreements exist. Examples include:

- Water Research Foundation (WRF)
- International Water Association
- Technology Innovation Agency
- NEPAD

KNOWLEDGE DISSEMINATION

The WRC aims to constantly improve its contribution towards knowledge as well as to enhance the sharing and dissemination of WRC-funded research findings. This is also linked to Government Outcomes/Outputs related to building skills, by addressing the building of future research capacity and improving knowledge dissemination. The WRC strives to improve its contribution towards the water-centred knowledge base in South Africa by enhancing the WRC knowledge-sharing activities and positioning.

Enhancing public understanding of water research: *the Water Wheel*

In the year under review, the WRC enhanced public understanding of science through the publication of t*he Water Wheel*. The magazine currently serves close to 8 000 subscribers and is published every two months. The WRC published six issues as well as a special edition of *the Water Wheel* in 2012/13.

Briefs

The WRC technical, policy and ministerial briefs are communication tools that aim to communicate, in a clear and brief format, the outcome of various research studies to the water sector, with special emphasis on non-technical professionals, policy- and decision-makers. For all finalised research projects, one- to two-page briefing notes are produced, which are short communiques highlighting research outcomes and sharing pertinent messages and recommendations. Another 36 technical and policy briefing notes were produced in 2012/13. (For easy reference, the number in brackets refers to the report or project number; all technical and policy briefs and reports are available electronically on the WRC website: www.wrc.org.za).

The following **technical briefs** were published in 2012/13:

1. Evaluating aquatic ecosystem services (1644)
2. Influence of irrigation on groundwater (K8-820)
3. Oestrogen activity in drinking water (1749)
4. Valuation of estuary services (1413)
5. Biobase user manual (K8-906)
6. Brominated flame retardants (K8-850)
7. Biologically enhanced primary settlement (bioflocculants) (K8-886)
8. Ecology of the Olifants River (K8-858)
9. Evaluation of clinoptilolite (1658)
10. South African groundwater governance case study (K8-958)

11. Guidance for toxicity tests (2611)
12. Knowledge Cafés – A template for learning (K8-874)
13. Real-time assessment of ecological Reserve (K8-881)
14. Water sector institutional landscape (2025; 1841)
15. Applicability of water footprints in SA (2099)
16. Development of a South African Guide for the Design and Operation of Waterborne Sewerage Systems (Seweraid) (1744)
17. Guideline for the selection of toxicity tests (1211)
18. Risk-based methodology to assess social vulnerability in the context of water infrastructure (1888)
19. Irrigation guidelines for annual ryegrass pasture irrigation (1744)
20. Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine-water (1834)
21. Parasites and related interactions in water resources and rural communities (1910)
22. The provision of FBW to backyard dwellers (1987)
23. Determining the evaporation rate of brine solutions (1895)
24. Ethnographic research to understand household water practices (1990)
25. Agroforestry systems for improved productivity through the efficient use of water (1480)
26. Influence of unpaved access roads on surface runoff, sediment (1807)
27. A manual for rural freshwater aquaculture (TT463)
28. Development of participatory provincial aquaculture programmes (1580)
29. New approach to estuary-based economic empowerment (1705)
30. Development of effective ways of extracting information from research (1978)
31. Fracking for shale gas exploration in South Africa (K8-896)
32. Reducing uncertainties in the estimation of groundwater recharge (1909)
33. The establishment and piloting of the technical assistance centre (1896)
34. The investigation of unsteady flow conditions at dam bottom outlet works (1914)

The following **policy briefs** were published in 2012/13:

- Future strategies for water services (1812)
- Can we manage our water better (1972)

Ministerial briefs are targeted messages aimed at communicating very specific research findings or knowledge generated from WRC research to Governmental ministers, most particularly, the Minister of Water and Environmental Affairs, the Honourable Ms Edna Molewa. These ministerial briefs have contributed substantially to an improvement in communication between the WRC and the Minister of Water and Environmental Affairs and contributed to her interest in the WRC-funded study on non-revenue water, availing herself to be the keynote at a WRC Dialogue on that topic, and emphasising the results at various other

high-level forums. The following **ministerial briefs** were published in 2012/13:

- Assessment of non-revenue water in South Africa (1996)
- State of the art: Fracking for shale gas exploration in South Africa and the impact on water resources (K8-896)

Distribution of WRC research and technology transfer reports

Table 1 indicates the number of WRC reports distributed to various stakeholder groups in 2012/13 and Table 2 lists the ten most popular reports in 2012/13 in terms of numbers of print copies requested.

Table 1: Cumulative sales of reports for 2012/13

FWR	208
Institutes	5 879
Municipalities	99
Private	10 639
Schools	34
State Library	379
University / University of Technology	1 632
WRC	635
WRC Board	10
TOTAL	19 515

Table 2: Most popular reports distributed during 2012/13

Report No	Title	KSA	Total
TT 129/00	*Quality of domestic water supplies, Volume 3: Analysis guide*	3	706
TT 491/11	*Sustainable use of South Africa's inland waters*	2	541
SP 31/12	*In the footsteps of giants*	5	522
TT 489/11	*Quality of domestic water supplies, Volume 2: Sampling guide*	3	449
1841/1/12	*The water sector institutional landscape by 2025*	1	295
TT 429/10	*Water related microbial disease guidelines*	3	257
TT 502/11	*Participatory development of provincial aquaculture programmes*	4	238
2099/P/11	*Applicability of water footprints in South Africa*	3	228
TT 463/09	*Manual for rural freshwater aquaculture*	4	213
TT 460/11	*What we and our children need to know, Volume 5*	3	182

Water SA

Water SA is the WRC's accredited scientific journal which contains original research articles and review articles on all aspects of water science, technology, engineering and policy. *Water SA* has been in publication since 1975 and includes articles by both local and international authors. The journal is issued quarterly (four issues per year). In the year under review, the WRC published five issues (four regular issues and one special edition).

Knowledge-sharing events

The WRC held a number of knowledge-sharing events in the year under review, including technical field visits and technical workshops aimed at enhancing knowledge transfer. Many of these were in collaboration with strategic partners in order to enhance research impact and knowledge uptake. During the year under review the WRC also launched the WRC Dialogues, a series of platforms enabling partners from all spheres of the water sector, including academia, government (all levels), civil society and industry, to come together to share their understanding and experiences of the challenges and problems, in order to build a stronger foundation for developing the solutions and interventions toward a better water scenario for South Africa and its development. The WRC Dialogues are guided by the principles of transparency, openness and honesty; plurality of perspective and inclusivity; mutual respect; a commitment to problem solving and mutual accountability; as well as knowledge sharing. The value of the WRC as convenor of these events lies in its ability to be a neutral knowledge broker as South Africa's premier water knowledge resource. Technical workshops, seminars, dialogues and launches held during the year under review included:

1. Technology Innovation Agency/ WRC workshop, 5 April 2012
2. Water Footprint Workshop, 7 April 2012
3. Sanitation stakeholder workshop, 19 April 2012
4. Workshop on Applying a Risk-based Approach to Secure ACID funding, 19 April 2012
5. WRC/Water Information Network South Africa (WIN-SA)/South African Institution of Civil Engineering (SAICE) Workshop to showcase good practice in wastewater treatment, 19 April 2012
6. Chris Swartz Water Utilisation Engineers/ WRC workshop on Wastewater Reclamation and Reuse, 8 May 2012
7. Chris Swartz Water Utilization Engineers/ WRC workshop on Energy Efficiency in the South African Water sector, 9 May 2012
8. University of Johannesburg/WRC workshop on Organic Compounds in Drinking Water, 9 May 2012
9. Workshop on Practical Application of Research: A Tool for Sewer Pump Problems, 9 May 2012
10. NEPAD Workshop, 17 May 2012
11. Workshop to share the draft Strategy Discussion Document on the Integration of Community Based Water Services Provision, 17 May 2012
12. Launch of the coffee-table book, *In the Footsteps of Giants – Exploring the History of South Africa's Large Dams*, 30 May 2012
13. Energy from Conduits workshop, 30 and 31 May 2012

14. WRC–Statistics SA water accounts meeting, 4 August 2012
15. WRC Dialogue Series launch, 14 August 2012
16. Workshop on Gender Mainstreaming in the State Sector, 17 August 2012
17. Wat-Indaba Dialogue on Eutrophication Management, 28 August 2012
18. DWA/WRC Wetlands Monitoring Workshop, 10 August 2012
19. Department of Education's Regional Coordinators Workshop specialising in Environmental Education, 30 August 2012
20. Visit by Chinese delegation, 31 August 2012
21. Second Regional African Water Leakage Summit, 29–31 August 2012 in Cape Town and 4–5 September 2012 in Johannesburg
22. WRC-TIA Strategic Workshop, 10 September 2013
23. Establishment of the Society for Ecological Restoration for South Africa workshop, 27 September 2012
24. Dialogue titled 'Our Water: Our Heritage and Legacy', 28 September 2012
25. Workshop on Exploring Water Data Coordination for Water Research in South Africa, 1 October 2012
26. WRC/DST Dialogue on 'Point-of-Use Water Treatment Systems and their Efficiency', 2 October 2012
27. Workshop on the Value of Ecosystems to Society, 18 October 2012
28. WRC/DST Reference Group Workshop on establishment of Water Centre, 26 October 2012
29. Workshop on the Green Village Project, 28 November 2012
30. Khuluma Sizwe Dialogue on The Right To Water, 9 November 2012
31. WRC/WISA/DWA and Energy and Water Sector Education and Training Authority Water Human Capacity Development session, 24 January 2013
32. Workshop on fracking related to groundwater, 6 February 2013
33. Workshop on sanitation technology in partnership with the IWA, University College London, non-governmental organisation, *ifak* (Institut für Automation und Kommunikation) Magdeburg, the University of KwaZulu-Natal and eThekwini Water and Sanitation, 13 February 2013
34. Workshop to prioritise research on sedimentation, 19 February 2013
35. Workshop in collaboration with the Department of Environmental Affairs and the South African National Biodiversity Institute (SANBI) on Ramsar Wetlands in South Africa, 28 February 2013
36. Workshop on Energy Efficiency in the Water and Wastewater Industry, 13 March 2013
37. Workshop to determine research priorities on agro-forestry, 19 March 2-13

Exhibitions

As part of its knowledge-sharing and dissemination activities the WRC participated in a number of exhibitions at conferences, symposia and workshops,

using these to disseminate information in the form of reports and other publications. Exhibitions in which the WRC participated included:

- Water Institute of Southern Africa Biennial Conference, Cape Town, 7–9 May 2012.
- The Conference of the Institute of Municipal Engineers of South Africa, Gateway Hotel, Umhlanga, 9–11 October 2012.
- The 13th Waternet/WARFSA/GWP-SA Symposium, Birchwood, Johannesburg, 30 October to 2 November 2012.

Internal Open Day

On 15 March, 2013, staff of the WRC descended on a Gold Reef City Mine Tour as part of a learning excursion especially aimed at internal staff members who may not have the opportunity to engage with WRC research content or project-related work in the field.

KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

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KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

NEW TT REPORTS

Guidance for sustainable on-farm and on-scheme irrigation water measurement
Isobel van der Stoep, Andrew Pott, Johannes Hendrikus Viljoen, Anna Maria Jansen van Vuuren

The results of this technology transfer project can be summarized in four key messages for potential users of measuring devices for irrigation water.

TT 550/12
ISBN: 9781431203734
Overseas Price: $35.00

Sustainable techniques and practices for water harvesting and conservation: farmer and extension manual
JJ Botha,
JJ Anderson, LF Joseph, RM Snetler, N Monde, F Lategan

The aim of this project was to select and implement water harvesting and conservation techniques that would assist two rural communities (Guquka and Khayaletu) in the Eastern Cape to improve their livelihoods by increasing their food production and developing their rangeland/livestock production systems. On-station and on-farm field experiments were conducted in order to test rainwater harvesting and conservation (RWH&C) techniques.

TT 542/12
ISBN: 9781431203512
Overseas Price: $35.00

Training material for extension advisors in irrigation water management. Volume 3: Extension learner guide; Part 9: Agricultural extension
Joseph Benjamin Stevens

It is generally recognised that extensionists provide the link between research output and solving the perceived problems which farmer's experience. All types of farmers, but specifically smallholder farmers, are dependent on extension services as a source of information and knowledge. Discussion forums organised by the Water Research Commission 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 become less effective.

TT 541/12
ISBN: 9781431203444
Overseas Price: $40.00

Training material for extension advisors in irrigation water management. Volume 2: Technical learner guide; Part 8: Irrigation crop and fodder production
Joseph Benjamin Stevens, Pieter Schalk van Heerden, Peter Reid, Andries Liebenberg, Eckardt Hagedoorn, Gerhard de Kock

TT 540/8/12
ISBN: 9781431203437
Overseas Price: $40.00

Training material for extension advisors in irrigation water management Volume 2: Technical Learner Guide; Part 7: Irrigation economics
Stefan van Zyl, Petrus Gerhardus Strauss, Joseph Benjamin Stevens

TT 540/7/12
ISBN: 9781431203420
Overseas Price: $35.00

Training material for extension advisors in irrigation water management. Volume 2: Technical learner guide; Part 6: Irrigation legislative context
Joseph Benjamin Stevens, Frans van der Merwe, Michiel C Laker

TT 540/6/12
ISBN: 9781431203413
Overseas Price: $35.00

Training material for extension advisors in irrigation water management Volume 2: Technical Learner Guide; Part 5: Irrigation engineering
Frans Buys, Joseph Benjamin Stevens, Stephanus Smal

TT 540/5/12
ISBN: 9781431203406
Overseas Price: $35.00

Training material for extension advisors in irrigation water management. Volume 2: Technical learner guide; Part 4: Irrigation water management
Joseph Benjamin Stevens, Frans Buys

TT 540/4/12
ISBN: 9781431203390
Overseas Price: $35.00

Training material for extension advisors in irrigation water management. Volume 2: Technical learner guide; Part 3: Agro climatology
Michiel C Laker, Pieter Schalk van Heerden, Joseph Benjamin Stevens

TT 540/3/12
ISBN: 9781431203383
Overseas Price: $35.00

Training material for extension advisors in irrigation water management. Volume 2: Technical learner guide; Part 2: Assessing of soil resources
Michiel C Laker, Joseph Benjamin Stevens

TT 540/2/12
ISBN: 9781431203376
Overseas Price: $45.00

Training material for extension advisors in irrigation water management Volume 2: Technical learner guide; Part 1: Soil-plant-atmosphere continuum
Joseph Benjamin Stevens, Pieter Schalk van Heerden, Michiel C Laker

TT 540/1/12
ISBN: 9781431203369
Overseas Price: $35.00

Training material for extension advisors in irrigation water management Volume 1: Main report
Joseph Benjamin Stevens, Pieter Schalk van Heerden, Frans Buys, Michiel C Laker

TT 539/12
ISBN: 9781431203352
Overseas Price: $45.00

Application of rainfall forecasts for agriculturally related decision making
Trevor Graeme Lumsden, Roland Edgar Schulze

The overall objective of this project was to develop and test techniques and models for translating weather and climate forecasts in South Africa into applications for decision support at a range of spatial scales in both rainfed and irrigated agricultural production and water management, in order to reduce risks associated with vagaries of day-to-day to seasonal climate variability.

TT 538/12
ISBN: 9781431202737
Overseas Price: $35.00

Technical aspects and cost estimating procedures of drip irrigation systems: main report irrigation guidelines for annual ryegrass pasture
Felix Britz Reinders, Bennie Grové, Nico Benadé, Isobel van der Stoep, Adriaan Smuts van Niekerk

Research funded by the Water Research Commission and projects completed by the Agricultural Research Council's Institute for Agricultural Engineering on the performance of surface and sub-surface drip irrigation found that the emission uniformity as measured in the field declined over time for all dripper types. This indicates a decline in efficiency due to clogging or lack of maintenance. Correct planning, design, installation and maintenance is essential and it is recommended that regular water quality analysis be carried out to identify potential clogging problems.

TT 524/12
ISBN: 9781431202737
Overseas Price: $35.00

Technical aspects and cost estimating procedures of drip irrigation systems: manual for designers
Felix Britz Reinders, B Grové, Nico Benadé, Isobel van der Stoep, Adriaan Smuts van Niekerk

Research funded by the Water Research Commission and projects completed by the Agricultural Research Council's Institute for Agricultural Engineering on the performance of surface and sub-surface drip irrigation found that the emission uniformity as measured in the field declined over time for all dripper types. This indicates a decline in efficiency due to clogging or lack of maintenance. Correct planning, design, installation and maintenance is essential and it is recommended that regular water quality analysis be carried out to identify potential clogging problems.

TT 525/12
ISBN: 9781431202744
Overseas Price: $30.00

Irrigation guidelines for annual ryegrass pasture
Melake Kessete Fessehazion, John George Annandale, Colin Stuart Everson, Amanuel Bokhre Abraha, Wayne Frederick Truter

The overall objective of this study was to promote efficient irrigation management of grass pastures (emphasis on ryegrass and kikuyu) by synthesizing available knowledge and generating new knowledge for improving water use efficiency by pastures. Italian ryegrass (Lolium multiflorum) was planted in an experiment conducted at the KwaZulu-Natal Department of Agriculture at Cedara located in the midlands of the KwaZulu-Natal mistbelt, one of the main milk producing areas of South Africa.

TT 521/12
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Nutritional value and water use of African leafy vegetables

André Oelofse, Wim van Averbeke

African leafy vegetables are commonly perceived to be heat and drought tolerant, use less water than conventional crops and provide a host of health benefits especially nutritional benefits. If these attributes are true, these crops could contribute greatly to the diet of especially poor, food insecure households, many of whom are living in drought stricken areas of the country. The research consisted of four main thrusts divided into specific research objectives. The review of nutritional status and strategies showed that under- and over-nutrition co-exist in the same communities and often same household. With respect to water requirements, there were distinct differences in water requirements between the different plants which varied from 340 mm to 463 mm.

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Production guidelines for African leafy vegetables

Willem Sternberg Jansen van Rensburg, Wim van Averbeke, Yacob Ghebretinsae Beletse, Martha Magaretha Slabbert

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Water use and nitrogen application for irrigation management of pasture production

Melake Kessete Fessehazion, Amanuel Bokhre Abraha, Colin Stuart Everson, Wayne Frederick Truter, John George Annandale, Magandaran Moodley

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Overseas Price: $25.00

Modelling agricultural non-point source pollution and economic-environmental trade-offs of pollution control measures

André Hermann Matheus Görgens, Simon Antony Lorentz, Michael van der Laan, Nebojsa Zarko Jovanovic, Nicolette Matthews, John George Annandale, Bennie Grové, Jacobus Johannes le Roux

This project developed an integrated modeling approach to the prediction of agricultural NPS pollution from field- to catchment-scale for phosphorus, nitrogen,

pesticides and sediments. A project team consisting of four individual Task Teams, comprising of one or more specialists within each of the domains of agricultural nutrients, sediments, pesticides, field-scale bio-physical modelling, catchment-scale bio-physical modelling, and agricultural economics, report on their activities in a series of five reports

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Investigation of unsteady flow conditions at dam bottom outlet works due to air entrainment during gate closure. Volume II: Computational modelling
Gerrit Basson

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TT 528/12
ISBN: 9781431202867
Overseas Price: $35.00

Drivers for wastewater technology selection: Assessment of the selection of wastewater treatment technology by municipalities in relation to the management capability and legislative requirements
M vd Merwe-Botha, G Quilling

This project identified the minimum requirements for effective and sustainable drinking-water service delivery within non-metropolitan water distribution networks to ensure acceptable drinking-water quality. Interviews with municipalities followed by site visits provided insight into current treatment plant and distribution network operation and maintenance procedures and the key factors that result in water quality failures in non-metropolitan networks. A web-enabled risk assessment tool was developed, as were practical guidelines aimed at different levels and/or users of the water service team, supported by two web-enabled tools available via the electronic Water Quality Management System (eWQMS).

TT 543/12
ISBN: 9781431203529
Overseas Price: $35.00

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex: Volume I: Inception report
Dave Edward Cleary Rogers, Godfrey Ganizani Mvuma, Alan Colin Brent, Suzanna Hester Helena Oelofse, Linda Keren Godfrey

This project looked at the key factors that influence the environmental sustainability of a large inland industrial complex: The Secunda Industrial Complex. The main finding for this study is that the long term increasing trend for unaccounted salt flows to the surface water systems indicates control of salt storage and disposal is the key factor for environmental sustainability. The economics of desalination and waste storage are driven by the cost of water and the management of post closure liabilities.

TT 544/12
ISBN: 9781431203659
Overseas Price: $30.00

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex: Inventory of inland salt production
Dave Edward Cleary Rogers, Christopher John Brouckaert, Phillip Hobbs

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TT 545/12
ISBN: 9781431203666
Overseas Price: $30.00

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex: Volume III: Development and assessment of technological interventions for cleaner production at the scale of the complex
Godfrey Ganizani Mvuma, Floor Hooijman, Alan Colin Brent, Suzanna Hester Helena Oelofse, Dave Edward Cleary Rogers

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TT 546/12
ISBN: 9781431203673
Overseas Price: $35.00

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex: Volume IV: Governance assessment
Godfrey Ganizani Mvuma, Floor Hooijman, Alan Colin Brent, Suzanna Hester Helena Oelofse & Dave Edward Cleary Rogers

TT 547/12
ISBN: 9781431203420
Overseas Price: $30.00

An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex. Volume V: Linking technologies to governance
Dave Edward Cleary Rogers, Godfrey Ganizani Mvuma, Alan Colin Brent

TT 548/12
ISBN: 9781431203697
Overseas Price: $30.00

Framework document for a WRC research programme on engineered nanomaterials
Victor Wepener, Bhekie Mamba, Ndeke Musee

Nanotechnology has taken the world of science by storm since it allows for the development of new materials with extraordinary properties. Examples of novel nanotechnology applications include the development of highly accurate and sensitive medical diagnostic devices, new ways of disease therapy, and the monitoring and remediation of basic water supplies.

TT 549/12
ISBN: 9781431203710
Overseas Price: $30.00

Tools to measure impacts and operations of rural small-community water supply in rural South Africa
Paul Jagals

The original question that spurred this work was whether small community water supply interventions in South Africa were beneficial to their recipients and to what extent.

The purpose of the research was two-fold - this report presents the method and the research to develop and apply it.

TT 534/12
ISBN:
Overseas Price: $00.00

Guide to SANIVEY – assessing user acceptance and functioning of mobile communal sanitation facilities in informal settlements
A Lagardien, C Muanda, A Benjamin

Technical innovations often lack sustainability due to a lack of attention or provision of operational requirements and community involvement. The application of these sanitation technologies in informal settlements however is lacking a framework for introducing, assessing the performance and functioning as well as an understanding of the perspectives of end-users of the new technology despite the existence of the national Strategic Framework for Water Services. This general framework does not clearly define "basic sanitation" in terms of technology.

This research was initiated to deal with this problem by investigating the current approaches to the implementation of a new sanitation technology, their acceptance and functioning in the natural setting of informal settlements.

TT 533/12
ISBN: 9781431203147
Overseas Price: $35.00

The WDM municipal balanced scorecard model user guide
Ronnie Mckenzie

Before implementing any new WDM intervention, it is normal practice to undertake an investigation of the area in question in order to assess the key problems and to propose a strategy to address them.

The resulting WDM strategy is usually a range of actions or interventions designed to address the main problems in order to reduce losses and or consumptive use.

TT 523/12
ISBN: 9781431202713
Overseas Price: $25.00

The state of non-revenue water in South Africa (2012)
R Mckenzie, ZN Siqalaba, WA Wegelin

This study builds on and follows on from the two previous assessments undertaken through the WRC. This study is the most comprehensive and detailed study of its type to date and expands on the knowledge acquired previously and through collaborative efforts with the DWA Regional Offices in the data gathering process. Data were gathered from 132 of the possible 237 municipalities throughout South Africa representing over 75% of the total Municipal water supply. From the analysis of the results, it was estimated that the current level of non-revenue water for the country as a whole is 36.8%. This figure is similar to the estimated world average of 36.6% but is on the high side when compared to other developed countries and low when compared to other developing countries. The use of percentages is not recommended by the International Water Association when referring to water losses or leakage levels as they can often be misleading.

TT 522/12
ISBN: 9781431202638
Overseas Price: $40.00

Compendium of water conservation and water demand management interventions and measures at the municipal level in South Africa
Mike Rabe, Dawid Maree, Rendani Ramano, Guy Price

The need for demand-side interventions that effectively reduce physical losses in water networks, artificial demand at the end-user level created through leakage, as well as apparent losses due to metering and billing deficiencies is abundantly clear.

TT 519/12
ISBN: 9781431202522
Overseas Price: $45.00

Ethnographic research methods to better understand household water practices -(DVD)
Iske van den Berg, Sarah Slabbert

This study aimed to test the viability of an ethnographic participative technique, i.e. the use of digital media in the form of a video camera, to do research about water related issues in rural communities. In addition its intention was to inform communication and education campaigns aimed at effective water management. Due to the nature of exploratory research, it was predicted that other unexpected outcomes could present themselves. The study responded to the call in developmental discourse that indigenous household water practices and innovations should be taken into consideration in development interventions and solutions for rural water problems.

TT 517/12
ISBN:
Overseas Price: $15.00

Modelling agricultural non-point source pollution and economic-environmental trade-offs of pollution control measures
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- WRC Report No TT 516/12: Modelling agricultural non-point source pollution and economic-environmental trade-offs of control measures
- WRC Report No 1516/1/12: Modelling nitrogen and phosphorus dynamics in cropping systems at the field scale
- WRC Report No 1516/2/12: Modelling the fate of pesticides: primary processes, non-point source data collection and guidelines
- WRC Report No 1516/3/12:
- Modelling nutrient and sediment dynamics at the catchment scale
- WRC Report No 1516/4/12: Modelling economic-environmental trade-offs of agricultural non-point source pollution control measures

TT 516/12
ISBN: 9781431202400
Overseas Price: $25.00

Guidelines for using the web-enabled Water Safety Plan Tool
Unathi Jack, Philip de Souza

Water Safety Planning is a systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery. In so doing the process allows for better understanding of water supply systems. Once the risk has been identified, control measures can be put into place to mitigate these risks.

TT 515/12
ISBN: 9781431202386
Overseas Price: $30.00

Technical Assistance Centre – small water and wastewater treatment plants
Chris Daniel Swartz

The Technical Assistance Centre (TAC) for small water and wastewater treatment plants was established to provide technical (but also non-technical) support to water services providers (WSPs) experiencing challenges with their water and wastewater treatment plants.

TT 510/12
ISBN: 9781431201976
Overseas Price: $35.00

The identification of a suitable culture organism to establish a bio-assay for evaluating sediment toxicity
Y Cloete, B Shaddock

Sediments act as a source and sink for a variety of organic and inorganic contaminants. These contaminants accumulate, resulting in extremely high concentrations even once the overlying water concentrations are at or below acceptable water quality guidelines. Any changes in the physical parameters of the overlying water can cause these pollutants to be released back into solution.

TT 532/12
ISBN: 9781431203109
Overseas Price: $40.00

Uthukela case study: Refurbishment vs replacement
Annalien Toerien, Priyal Dama-Fakir, Henlo du Preez

South Africa has approximately 850 municipal treatment plants. In a recent Green Drop evaluation carried out, 55% of the treatment plants investigated scored below 50%, indicating that drastic improvements are required. This trend in many cases is due to minimal maintenance and replacement, causing infrastructure and equipment to deteriorate to the extent that replacement is considered. However, refurbishment is an option that should be considered.

TT 480/12
ISBN: 9781431202225
Overseas Price: $40.00

The freshwater science landscape in South Africa, 1900–2010: Overview of research topics, key individuals, institutional change and operating culture
Peter Ashton, Dirk Roux, Charles Breen, Jenny Day, Steve Mitchell, Maitland Seaman, Michael Silberbauer

This study set out to record the evolution of aquatic sciences in South Africa since 1900, identify the external driving forces that helped to direct research, pinpoint the individuals and institutions responsible for shaping the ways in which aquatic sciences developed, and determine the extent to which aquatic sciences have contributed to effective management of South Africa's water resources.

TT 530/12
ISBN: 9781431202805
Overseas Price: $30.00

Investigation of unsteady flow conditions at dam bottom outlet works due to air entrainment during gate closure. Volume I: Physical modelling
Eddie Bosman, Gerrit Basson (Editors)

The Berg River Dam is equipped with the first multi-level draw off environmental flood release outlet in South Africa and can release flows of up to 200 m^3/s. The outlet is controlled by a radial gate and is protected by a vertical emergency gate. Commissioning tests of the emergency gate in 2008 found that large volumes of air were expelled from the air supply shaft designed to reduce expected negative pressures in the conduit during emergency gate closure.

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TT 529/12
ISBN: 9781431202874
Overseas Price: $40.00

Development of a tool for assessment of the environmental condition of wetlands using macrophytes
F Corry

This is the last report of 11 reports emanating from Phase 2 of the WRC Wetland Health and Importance (WHI) research programme. In addition to biotic indices using macrophytes and aquatic invertebrates, a method for the assessment of temporary wetlands during dry conditions and a method for the assessment of the cumulative impacts of human activities at the landscape and catchment levels on wetlands was developed. The socio-economic aspects of wetlands ecosystem services were investigated and case studies presented.

TT 436/12
ISBN: 9781770059283
Overseas Price: $45.00

Groundwater resource directed measures (2012 edition)
Ingrid Dennis, Kai Witthüsser, Koos Vivier, Rainer Dennis, Andrew Mavurayi
To be able to implement the NWA, the Minister needs to ensure that the tools and expertise required to implement the Act are available. This manual addresses the methods and procedures needed to implement Resource Directed Measures (RDM).

To distinguish between RDM in general and RDM related to groundwater, the term Groundwater Resource Directed Measures (GRDM) will be used when the focus is only on groundwater.

TT 506/12
ISBN: 9781431203217
Overseas Price: $45.00

A 2011 perspective on climate change and the South African water sector
RE Schulze

This project was initiated as a result of, among others disparities in water availability and access to water experienced by many of the country's people, and since these could well be amplified by climate change. Other factors that were taken into account were that South Africa is characterised by a highly variable climate added to an already stressed water situation and an imperfect governance system.

TT 518/12
ISBN: 9781431202683
Overseas Price: $40.00