KNOWLEDGE REVIEW

2015/16

WATER RESEARCH COMMISSION

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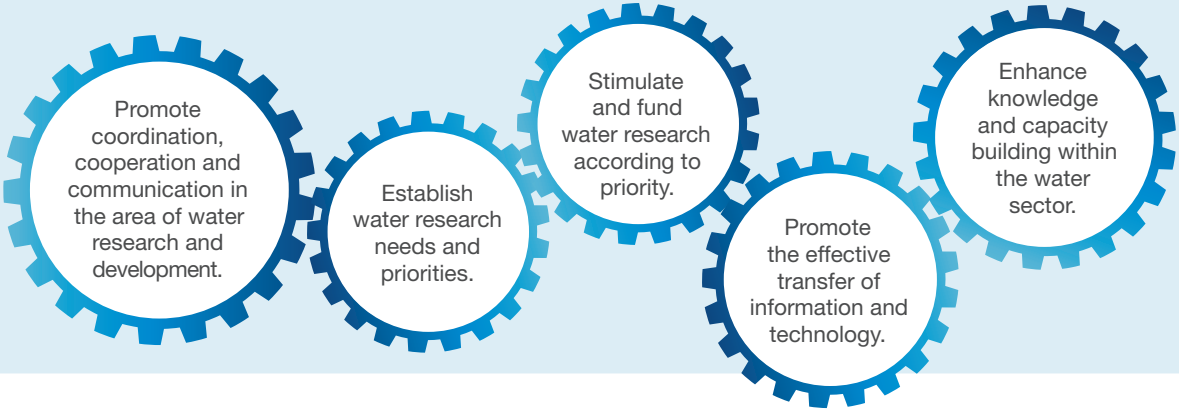
INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2015/16, 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 2015/16 was set on the basis of the WRC's Strategic Plan. The WRC continued to invest in the creation of knowledge via its four main key strategic areas (KSAs): **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management**, and **Water Utilisation in Agriculture** (Figure 1). **KSA 5: Business Development, Marketing and Communications** provides strategic direction to the business development, communication, marketing and branding goals of the WRC, with an emphasis on research uptake and knowledge dissemination.

About the WRC

The WRC was established through the Water Research Act (WRA), Act No. 34 of 1971. The WRC operates and accounts for its activities in accordance with the Public Finance Management Act (PFMA), Act No. 1 of 1999 as amended, and is listed as a Schedule 3A public entity. The primary function of the WRC is to:



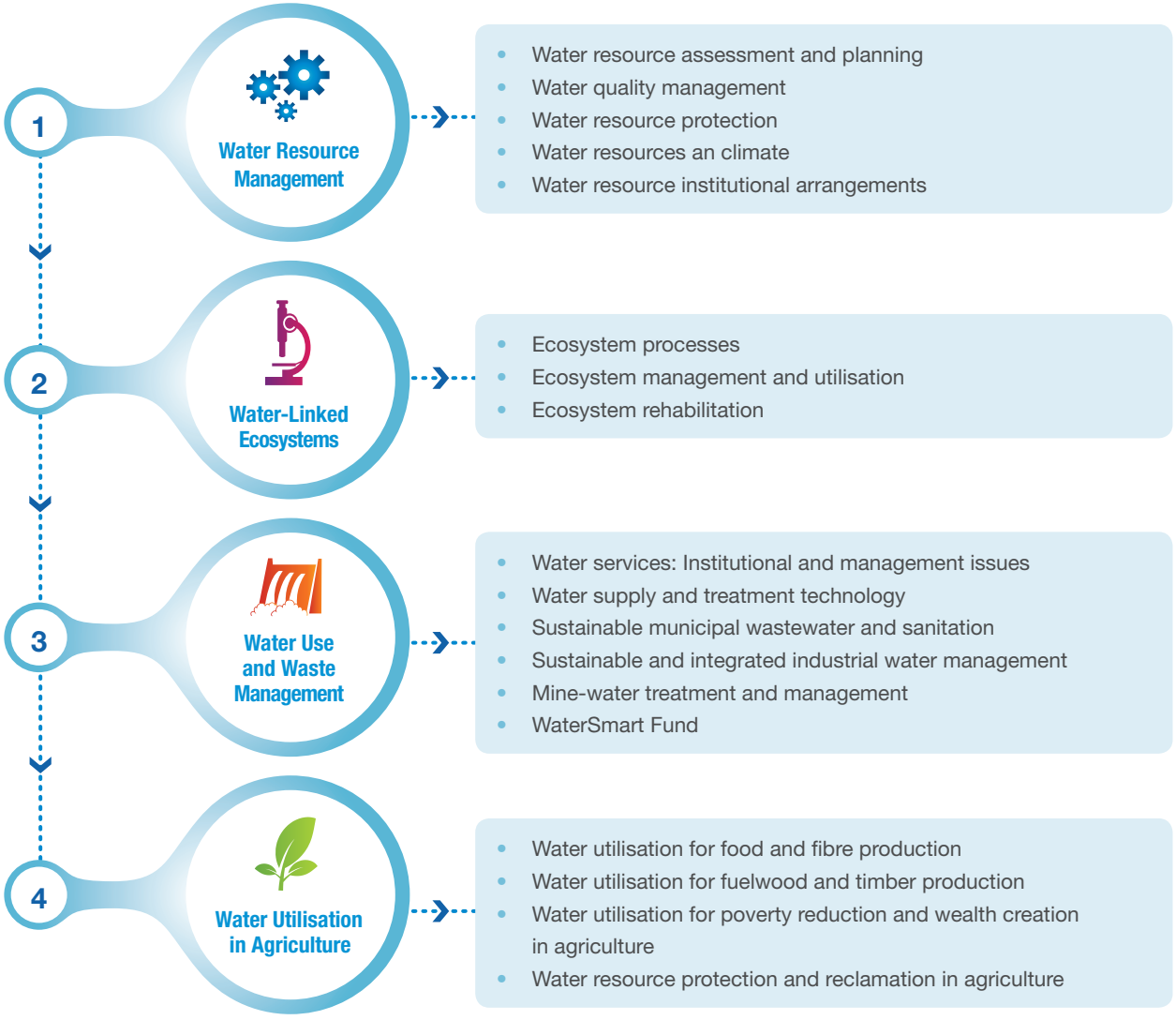


Figure 1: WRC Research Key Strategic Areas

STRATEGIC OUTCOME-ORIENTED GOALS

In addition to contributing to several Government Outcomes, the WRC's strategic outcome-orientated goals (Figure 2) comprise five impact areas based on the operationalisation of the WRC Knowledge Tree (Figure 3), a fundamental guiding framework and corporate planning tool used by the WRC to define, measure and evaluate research impact. The WRC strives to achieve as many of the WRC Knowledge Tree impact areas as reasonably possible in the research that it funds. This applies within a research project, to post project actions, and to follow-on projects.

Figure 2: The WRC's strategic outcome-orientated goals

Inform policy and decision-making

The WRC aims to commission appropriate evidence-based knowledge generated to guide decision-making, influencing the development of policy, practice or service provision, shaping legislation, altering behaviour, contributing to the understanding of policy issues, and reframing debates.

Develop new products and services for economic development

The WRC capitalises on those projects that have potential to develop new intellectual property or to introduce innovations which create new or improved technologies, products and services that can be used in the real economy. Effectively, this is the WRC's contribution to job creation and economic development through water science innovations.

Enhance human capital development (HCD) in the water and science sectors

The WRC strives to have high levels of student participation in its projects. Although the emphasis is on post-graduate degrees, inclusion of undergraduates has also been investigated. There is also a particular emphasis on previously-disadvantaged individuals (PDIs) and women. The WRC also aims to support institutional development through mentorship provided to new research leaders.

Strategic Outcome-Oriented Goal

Drive sustainable development solutions

The WRC prioritises those projects that provide sustainable development solutions that have had positive effects on the environment, economy and society, including: protection of water resources, optimal water use, equity between generations, equitable access, environmental integration and good governance. Additionally, this goal focuses on developing knowledge products that are fit-for-use to ensure the uptake of research.

Promote transformation and redress

This goal focuses on growing PDI involvement/leadership in projects, as well as helping to promote socio-economic development through the reduction of poverty and inequality in South Africa, particularly of marginalised groups such as women and youth.

Empower communities

The WRC places an emphasis on projects that (a) include communities not only as end-users of research but as active participants in the research process from the project design phase; (b) have a direct impact on the livelihoods of communities through water-related interventions; and (c) build sufficient capacity to assist with the post-project sustainability of those interventions.

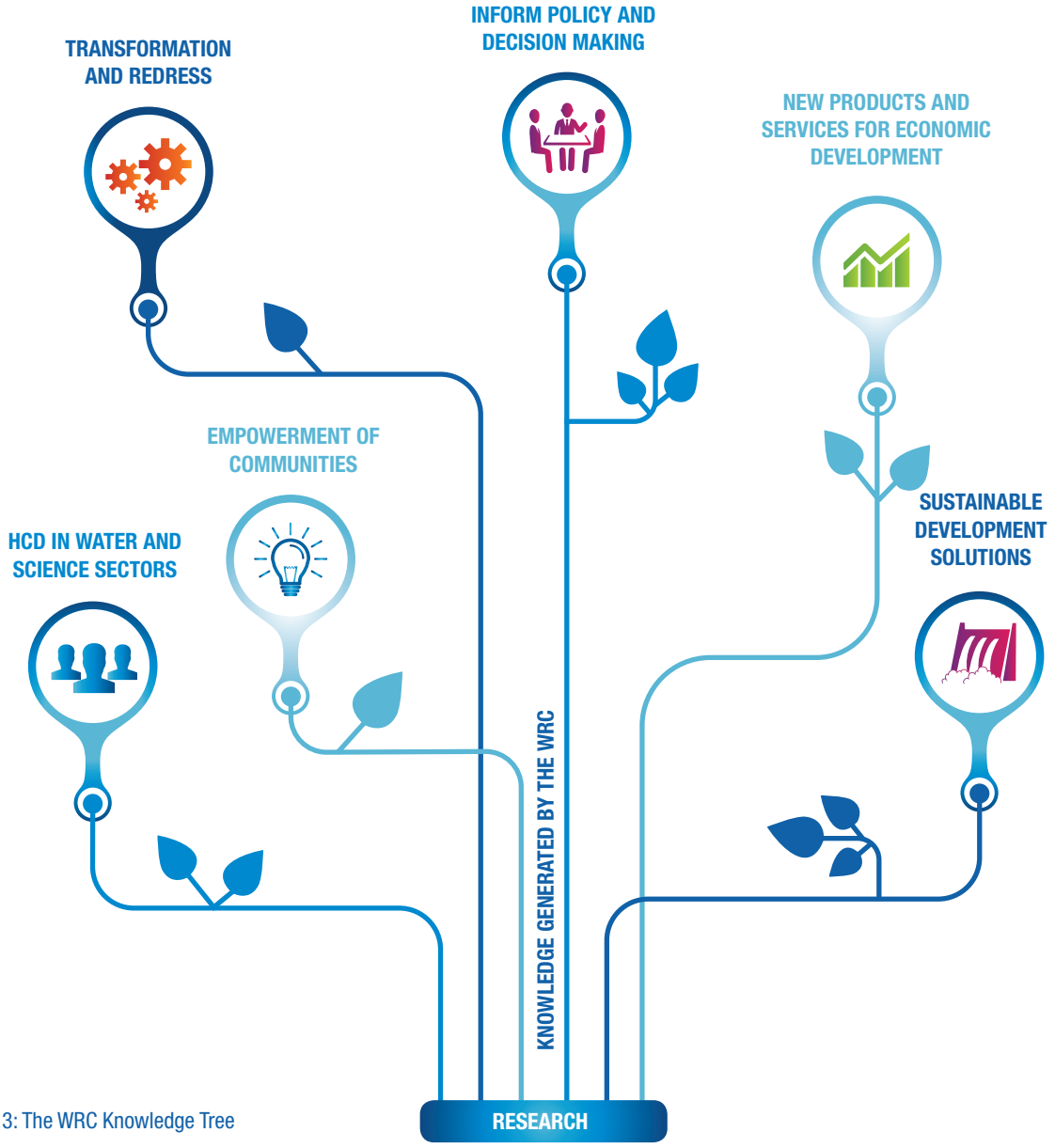


Figure 3: The WRC Knowledge Tree

SUPPORTING RESEARCH PROJECTS

In 2015/16, the WRC initiated 90 new projects and also completed 90 projects. This represents a cumulative increase in the amount of new and finalised research projects funded over the past 5 years. Over the past 5 years the WRC has finalised 440 research projects (Figure 4) indicating a significant contribution to knowledge in the water sector, with an average number of 87 projects finalised per year. Over the same 5-year period 445 new projects (Figure 5) were initiated, ensuring the continuous contribution of new knowledge to the sector.

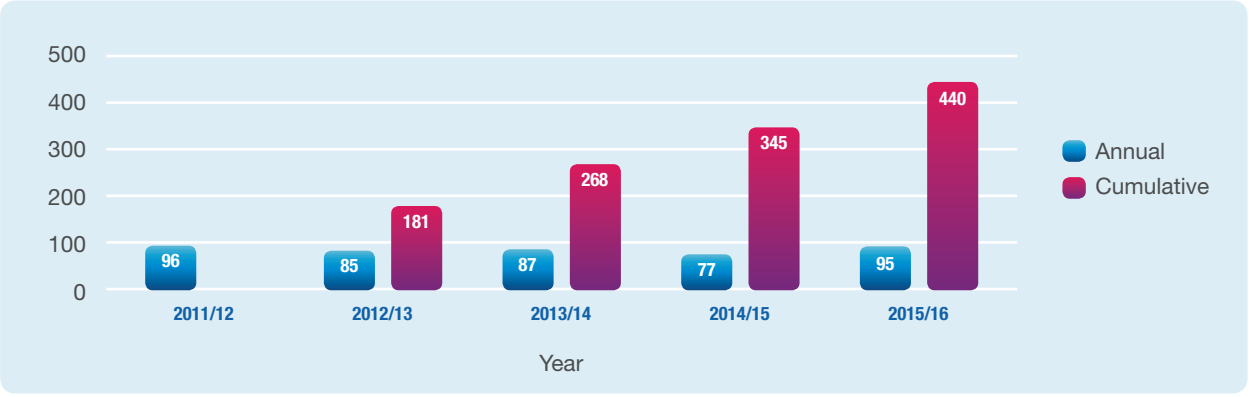


Figure 4: Annual and cumulative number of projects finalised over the past five years

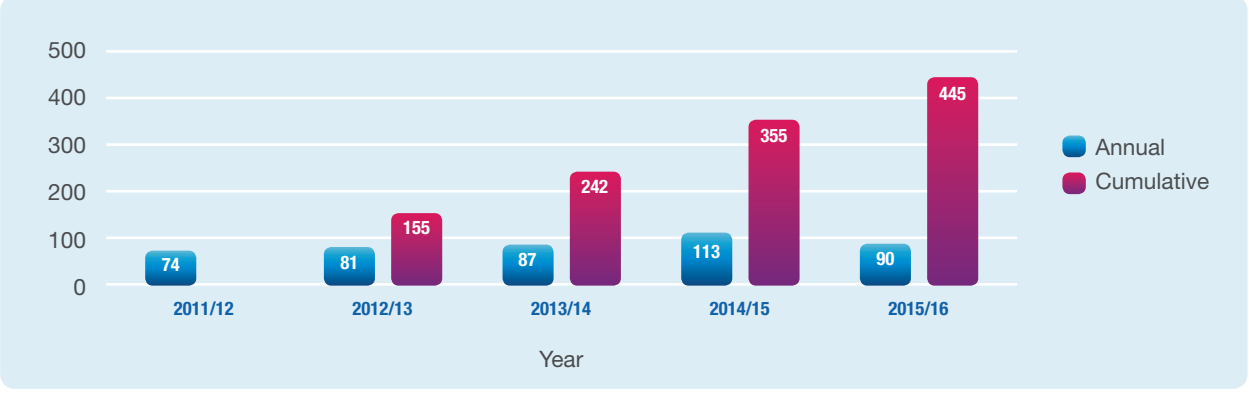


Figure 5: Annual and cumulative number of projects initiated over the past five years

During the 2015/2016 financial year, a new branch was established, namely Innovation and Impact. The primary reason for the renewed focus on achieving impact is that, as a public entity, the WRC forms part of a Government that strives to improve the lives of its citizens. The WRC is increasing the emphasis on the need for evidence of economic and social returns from its investment in research. This has the potential to enhance social and economic wellbeing across all sections of society by means of:

- Improving the effectiveness and sustainability of public, private and third sector organisations
- Improving social welfare and cohesion
- Increasing economic prosperity, wealth, and job creation
- Enhancing cultural enrichment and quality of life

The percentage utilisation of research project funds by the KSAs during 2015/16 (Figure 6) indicates that approximately 6% was invested in projects that focused on Innovation and Impact, whereas 94% was invested in research and development. Going forward, the emphasis will shift to the Innovation and Impact branch, which will have an effect on the future utilisation of research project funds.

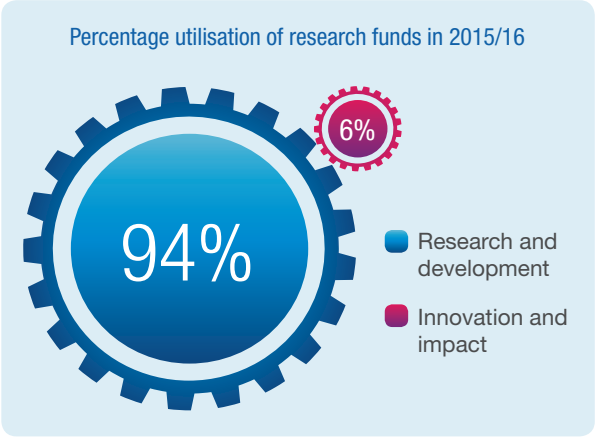


Figure 6: Utilisation of research funds

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 serving as members of steering committees as well as representatives of new proposals.

In recent years the WRC has adjusted its portfolio to train and mentor new research leaders. More than 60% of research leaders on new projects are now from designated groups and most are younger than 50 years old. This is both assisting with the national transformation project as well as building the next generation of researchers. Historically, most projects lay within universities; however, it is encouraging to note that 24 WRC projects were being led by small-, medium- and micro-enterprises in the past financial year. While stakeholder participation in research has always formed an important part of WRC research activities, this year the Commission is also playing increased emphasis on community participation as a KPA. The WRC is proud to report that it has 9 community-based research projects in its project portfolio. The WRC is further encouraged by the number of innovations and/or new products stemming from its research. No less than 20 innovations were recorded in the past financial year.

WRC RESEARCH PORTFOLIO 2015/16

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2015/16 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

SCOPE

Fundamental global challenges affect the scope of KSA 1, such as climate change, population growth and urbanisation. The results of these drivers are clear pressure manifestations, such as demand far exceeding available freshwater resources, increased competition between sectors and deteriorating water quality.

The current situation, in which there is perpetually growing water demand and competition, is leading to deepened water insecurity in certain locations. The ability and preparedness of sectors to engage on water issues has improved with the enhanced comprehension of water shortages, yet the issue of water management is not as high as it should be on the national political agenda. Water quality remains a concern, where causes and management options are well researched but the need to implement control and/or incentive measures requires additional work. Deteriorating water quality has compromised water resource integrity and its resilience in adapting to natural as well as man-induced impacts, and to be able to support national as well as regional sustainable development.

Tensions around decisions about allocations and de-allocations, water tenure, and trade-offs in satisfying demands for food security, energy and sustained environmental services will become much more heightened. In response, research focusing largely on understanding the barriers to policy implementation at the different levels is required. The democratisation of the management of water resources, through decentralised management, will need to amplify the developmental dimension, in order to ensure equitable access to water, its use and economic benefits.

The main aim of this KSA is to provide 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 unit operates in five thrusts, ranging from institutional arrangements, reform and governance to catchment assessment and planning, water quality management, water resource protection, and water resources and climate.

Apart from the problems of water resource limitations and induced scarcity, South Africa has specific challenges relating to inequities in the physical, social, administrative and institutional access to this important resource. This applies especially to the poor and disempowered majority, whose ability to pay for water is limited.

OBJECTIVES

The strategic objectives of KSA 1 are as follows:

- To establish better freshwater governance aimed at facilitating equitable, productive and sustainable use of water resources among all users
- To develop a deeper scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning
- To consolidate the vast amount of existing water quality–related research outputs in priority domains and to transfer this knowledge whilst being alert to emerging issues
- To contribute research towards a reliable supply of good quality water for the health, and environmental, social and economic wellbeing of the country

THRUSTS AND PROGRAMMES

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 ground-breaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource 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. This is considered as one of the tools for assisting in learning and allowing for dialogue to take place around options. Other tools exist which will also be explored in due course such as Game Theory especially in support of water allocation options.

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 and infrastructure	**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. 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 4: Climate change and water resources	**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 5: New water and water security	**Scope:** Secure and sustainable access to water is essential for a wide range of critical uses such as human health, economic growth, food security, etc. However, in semi-arid environments such as South Africa, conventional water sources are not sufficient to meet the ever growing demand. Therefore, the understanding and assessments of alternative sources of water such as fog water, desalination, water transfers, etc., is essential. The programme will also promote research on transboundary water issues (with respect to water quantity and quality) to ensure water security for South Africa. Other issues to be researched include cooperation on shared surface water and groundwater resources, as well as the integration of social, economic, and environmental considerations as key components of sustainable water resource development.

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 in 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 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 institutional 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.

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).

RESEARCH PORTFOLIO FOR 2015/16

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Advancing Strategic Adaptive Management (SAM) as a framework for implementation of IWRM by catchment management agencies

University of the Witwatersrand; Inkomati Catchment Management Agency; Department of Water and Sanitation

No. 2072

This project has developed the Strategic Adaptive Management (SAM) method to enable water management and governance to effectively take place in a changing environment where expectations also change. The nature and form of CMAs as institutions is not well understood in South Africa. This process enabled the Inkomati Usuthu CMA to develop its catchment management strategy and in so doing the SAM approach has become entrenched within the institution.

Cost: R1 517 975
Term: 2011-2015

Key interventions to improve local groundwater governance

University of the Western Cape

No. 2238

Groundwater management is the process of implementing decisions about groundwater. Groundwater governance includes groundwater management and the process of making the decisions that groundwater management implements. Both governance and management can occur at various scales. Research has shown groundwater governance at the local scale in South Africa to be weak or non-existent. The purpose of this project was to identify and prioritize key interventions that can improve local groundwater governance in South Africa. An extensive report has been compiled to highlight and unpack the interventions, so as to provide insight into their practical implementation.

Cost: R300 000
Term: 2013-2015

A compendium of the legal narrative of the South African White Paper and National Water Act of 1998

Business Enterprises University of Pretoria; GHT – Southern Africa; University of Pretoria; Global Water Partnership Southern Africa; Pegasys Strategy and Development (Pty) Ltd

No. 2250

The demise of Apartheid and the election of a new non-racial and democratic government in South Africa in 1994 remains a landmark for most development discourses in the country. Since then, public policy reform discourses have gained more visibility in various sectors of the economy (water included). The desired reforms in the water sector were translated, firstly, into a statement of policy (White Paper on a National Water Policy, 1997) and then into legislative instruments, namely, the Water Services Act (1997) and the National Water Act (1998). The study was informed by the view that legal history is important for the South African water sector. The South African water law history needed to be documented in order to revisit and institutionalize the principles and arguments used during the development stages of the water law review. Due to the loss of institutional memory in the water sector, sometimes difficult questions are now asked. For example, why do we need catchment management agencies? What was the thinking behind establishing water user associations? Indeed, what was the major rationale for changing water institutions and insisting on water re-allocation in South Africa after 1994? Any attempt to answer these questions will reveal that the South African water law legal history is closely connected to the democratic transition in South Africa during which values of equity, efficiency and sustainability were and continue to be held in high esteem. It is also set in the wider context of the anticipated socio-economic changes in society post-1994. Therefore, if questions arise today regarding the extent to which change in the desired direction has occurred or been hindered in the South African water sector post-1994, it will be necessary to re-visit the then prevailing baseline motivations and objectives of reform during the design stage or law review process. This study was important in that it collected and collated documents and knowledge that articulate these baseline motivations and objectives as reflected in the dominant discourses and information sources used during the review of the water law. Documenting the legal history of water law in South Africa enables scholars to record the evolution of the water law and the motivations for this evolution with a view to better understanding the origins of the various principles enshrined in the law and policy and how these may be better addressed in the foreseeable future.

Cost: R1 500 000
Term: 2013-2015

Programme 2: Compliance and enforcement

A management tool for the Inkomati Basin with focus on improved hydrological understanding for risk-based operational water management

University of KwaZulu-Natal; UNESCO-IHE

No. 1935

The establishment of an improved hydrological understanding of the Inkomati Basin, with the identification of variability in the system's hydrological and managerial drivers, were the main focus areas of this project. It determined the present and future decision-making requirements for optimal management of the basin's water resources given devolved responsibilities to the CMA. The Inkomati CMA STEEP approach was the basis but is not necessarily only aimed at one CMA. There is potential that the product can be used by other CMAs in South Africa and in the region as a whole.

Cost: R1 800 000
Term: 2009-2014

Considering alternative dispute settlement practices for water resources management In South Africa

Stellenbosch University; Water Matters

No. 2077

This research aimed to consider the extent to which alternative dispute resolution can provide real solutions for the effective management of water disputes and conflict. Despite significant changes in the legislative and administrative framework that governs water usage in South Africa, the legislation has in practice retained the same basic model for dealing with water disputes that was developed under the Roman Dutch legal system of the Apartheid years – a lawyer driven, confrontational model, based on adversarial litigation. This research acknowledges the widespread adoption of collaborative dispute resolution processes, such as mediation, as the preferred dispute settlement mechanism in many areas of government.

Cost: R1 370 232
Term: 2011-2015

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The establishment of rain gauge networks for rainfall estimation calibration of the South African new weather radar network

North-West University (Potchefstroom); South African Weather Service

No. 2062

Advancing radar rainfall estimates in South Africa is extremely important. The South African Weather Service (SAWS) upgraded its network of radars between 2009 and 2012 at a cost of millions of Rands. This new radar network includes 9 single polarized S band radars, 1 dual polarized S band weather radar, 2 mobile dual polarized X band radars and 5 C band radars. The initial objective of this study was to calibrate this radar network to improve the accuracy and reliability of the data measured. Due to unavailability of SAWS radar network for research, the

North-West University purchased and installed its own Parsivel disdrometer radar, called NWU Lekwena weather radar, in Potchefstroom in August 2014. Preliminary (1 year) results from this radar have highlighted the need to customise radars from overseas for South African climatic conditions. After the calibration and customisation, results from this radar were compared to the newly installed rainfall network, and the results were highly correlated. The combination of the ongoing rainfall monitoring from the rain gauge network and rainfall measurement from the radar has greatly improved rainfall estimates in the area covered by this radar.

Cost: R1 100 000
Term: 2011-2015

A methodology to create a South African river network with hydraulic intelligence

ARC (Institute for Soil, Climate and Water)
No. 2164

In this study a semi-automated methodology for creating a robust, countrywide, accurate river network coverage for use in GIS projects and other planning initiatives in South Africa, was assessed and developed. The assessment and development of this methodology was achieved by creating river networks through improvement of 1:50 000 river lines from NGI, adopting a suitable modelling approach to select river lines from SRTM flow paths for transboundary catchment areas, mapping of vegetation from remote-sensing data as supportive information in arid environments, and mapping of open water bodies from remote-sensing imagery as supportive information in identifying river lines and the perennial status of a river. The methodology was tested in two climatically different case studies – the wetter Mzimvubu catchment (T3) in the Eastern Cape and the arid Molopo catchment (D42) in the Northern Cape, and was found to be sufficiently robust.

Cost: R1 000 000
Term: 2012-2015

Revision of the mean annual precipitation (MAP) estimates over Southern Africa

Pegram and Associates (Pty) Ltd; Department of Water and Sanitation; University of Stuttgart; University of Cape Town; South African Weather Service
No. 2241

The currently available maps and figures describing mean annual precipitation (MAP) and mean monthly precipitation (MMP) over Southern Africa were in need of updating. To do this as well as possible and to add an important measure describing the reliability of these estimates, new mathematical and statistical tools for infilling gauge data and interpolating the results onto a spatial grid were developed and compared with existing methods. The MAP and MMP maps of areal estimates over quaternary catchments in the region, with tags of uncertainty, were produced for the use of hydrological practitioners. These maps and the algorithms developed and used are available on a CD accompanying the report. Additionally the links between satellite estimates of rainfall, in particular TRMM, were compared against spatially interpolated raing auge data over the TRMM pixels. The result was a reasonable match over months, but a poor match at the daily scale. As an alternative approach, a novel proposal for quantile-quantile adjustment of TRMM (and its successor GPM) was mooted in the report.

Cost: R1 800 000
Term: 2013-2016

Sediment yield modelling in the uMzimvubu River catchment

ARC (Institute for Soil, Climate & Water); Department of Agriculture, Forestry & Fisheries

No. 2243

Siltation of river impoundments is a global phenomenon which affects the capacity and life expectancy of dams. The proposed development of the Ntabelanga Dam in the Mzimvubu catchment is prone to this phenomenon as large parts of the catchment consist of highly erodible soils with widespread evidence of soil erosion. However, the exact source of the material needs to be determined in order to inform land-use management interventions upstream of the proposed dam. Most regional studies across the globe emphasize the sheet and rill aspects of the erosion cycle, but few map and/or model gully erosion at large spatial scales. This study models the major soil erosion processes in the catchment, as well as the sediment yield contribution from sheet-rill and gully erosion for the whole study area. Understanding these processes will enable area-specific management intervention and erosion control measures that are currently planned for the future dam site at Ntabelanga on the Tsitsa River. The study was undertaken using ArcSWAT and remote-sensing techniques in an integrated GIS approach. The results produced a total sediment yield map of the Mzimvubu River Catchment, with an average of 5.0 t/ha·yr. In the Ntabelanga Dam Catchment the sediment yield ranges between 1 t/ha·yr upstream to 22.5 t/ha·yr at the future dam outlet. Based on the sediment yield results and digital elevation data in a GIS, the life expectancy of the dam could be between 34 and 49 years without proper siltation prevention or design measures.

Cost: R550 000
Term: 2013-2015

The use of GIS and remote sensing techniques to evaluate the impact of land-use and land cover change on the hydrology and water resources of Luvuvhu River Catchment in Limpopo Province

University of Venda; ARC (Institute for Soil, Climate & Water)

No. 2246

Increase in population and associated development in Vhembe District Municipality have subjected the Luvuvhu River catchment to considerable land-use change over the past decades, impacting negatively on the hydrology. Remotely-sensed data and ground survey methods were used to evaluate the land-use and land cover change. Vegetation data were captured and automated in a GIS-compatible format, which provided flexibility in mapping, data analysis, data management and utilization. The SWAT model was used to simulate the impact of land-use and land cover on hydrology at the Hydrological Response Unit level. Recent developments on hillsides and hilltops in the catchment were of concern as they were impacting on the hydrological processes through the reduction of infiltration and surface runoff, and were preventing rain water from reaching natural waterways.

Cost: R555 000
Term: 2013-2015

Programme 2: Surface water / groundwater hydrology

Investigating projected changes in the nature of extreme rainfall over South Africa during the 21st century

University of Cape Town; University of Edinburgh

No. 2240

Extreme rainfall in South Africa is associated with particular synoptic environments, which can be quantified to assess changes in the nature of extreme rainfall environments as a result of greenhouse gas warming in the future. Trends in observed extreme rainfall data show a general increase in the frequency of occurrence of extreme rainfall events and the synoptic environments associated with these events. Downscaled future projections over southern Africa indicate synoptic environments associated with extreme rainfall are likely to increase in frequency over the tropical and sub-tropical summer rainfall region with the magnitude of the change higher in the tropics. Over South Africa, increases in frequency and intensity of extreme rainfall are projected over the eastern parts of South Africa, especially over the Drakensberg while decreases are projected over the western and southern parts of the country. This study has demonstrated that changes in extreme rainfall, when understood in the context of the driving synoptic environment, provide defensible messages of projected changes in the nature of extreme rainfall.

Cost: R418 000
Term: 2013-2016

Programme 3: Water resource planning and infrastructure

Implementation of a South African National Standard for Water Retaining Structures

Stellenbosch University; University of KwaZulu-Natal (Westville)

No. 2154

This project developed a South African design standard for the design of reinforced concrete liquid retaining structures. The development process and creation of supporting documentation are presented. The developed standard (SANS 10100-3) has been accepted as an official SABS TC Draft Standard to be prepared for public comment and subsequent publication as a National Standard.

Cost: R790 000
Term: 2012-2015

Development and Assessment of an Integrated Water Use Quantification Methodology for South Africa

University of KwaZulu-Natal; Pegram and Associates (Pty) Ltd; WaterWatch; Inkomati-Usuthu Catchment Management Agency

No. 2205

South Africa is a water-scarce country with regions where demand for water exceeds natural supply. The actual water use by different water use sectors in most parts of the country is unknown, and thus large volumes of water resources are unaccounted for. In this project, a

methodology was developed to quantify water use and availability, and to represent this information in the form of water resource accounts describing the water resources within a catchment, including water inflows, water use by different sectors and water outflows. The methodology has a strong land cover/use focus, and a hierarchical system of land cover/use classes which was developed to enable sectoral water use to be reported at different levels of detail. It was tested in two case study catchments (uMngeni and Sabie-Sand) where annual water resource accounts for 2011, 2012 and 2013 were compiled in each case study catchment.

Cost: R2 500 000
Term: 2012-2015

Extending the Ogee spillway relationship to accommodate the unsymmetrical upstream cross sectional details, the relative orientation of the wall structure and the influence of the curvature of the dam structure

University of Pretoria; Department of Water and Sanitation; South African Commission on Large Dams (SANCOLD)
No. 2253

The current design of Ogee spillways is based on relationships for 2-dimensional flow conditions. It was postulated that 3-dimensional flow should be incorporated to ensure an effective Ogee spillway design. It was hypothesized that the following parameters will influence the geometric profile of the Ogee curve: the asymmetricity of the upstream approach channel; the orientation of the spillway relative to the direction of flow; and the radius/curvature of the dam wall. The research showed that when reviewing the first two parameters, there was a reduction in the discharge coefficient and that the current Ogee relationships underestimate the required form of the spillway. Furthermore a higher upstream energy level (up to 18%) is required to obtain a profile which will prevent breakaway. These results also suggest that the capacity of existing spillways might have to be reassessed. It is recommended that the effect of radius/curvature of the dam wall be investigated and that a design guideline for Ogee spillways be compiled considering all of the 3-dimensional flow parameters.

Cost: R300 000
Term: 2013-2015

Programme 4: Climate change and water resources

Investigating climate change effects under altered land uses on water yield and downstream ecosystem services

Golder Associates Africa (Pty) Ltd; Eco-Futures; University of KwaZulu-Natal (Pietermaritzburg)
No. 2156

Sensitive ecosystems and communities rely on local catchments for water supply and other goods and services, many of which are threatened by land degradation through overgrazing and poor resource management, as well as by the spread of invasive plant species due to human movements, which can lead to altered hydrological responses, and competition with indigenous species. These human-induced catchment interventions result in ecosystem imbalances which affect water quality and resource supply to downstream users. This project aims, through detailed hydrological modelling, to estimate the effects of invasive plant species and

overgrazing on water yields and ecosystem services under different climatic regimes and topographic conditions found in South Africa. This information should be used to inform water resource managers regarding potential impacts, and allow them to make decisions regarding rehabilitation and/or preventative efforts with regard to these factors in order to maximise the security of water supply and minimize detrimental effects of sediment yield. This approach could also aid managers with regards to getting the maximum return on rehabilitation efforts in their catchment, in the optimal location.

Cost: R900 000
Term: 2012-2015

Stratospheric and tropospheric radiative forcing of Southern African climate variability and change

CSIR; South African Weather Service; University of the Witwatersrand

No. 2163

This project explored the effects of various forms of tropospheric and stratospheric radiative forcing (e.g. Antarctic stratospheric ozone, increasing CO_2 concentrations and time-varying aerosol forcings) on southern African climate variability and change. A large set of sensitivity tests, following the experimental design of the Atmospheric Model Intercomparison Project (AMIP), was performed for this purpose. An ensemble of projections of future climate change has also been analysed, to investigate the relative importance of enhanced CO_2 concentrations and recovering stratospheric ozone in forcing southern African climate during the 21st century. The simulations have provided new insight in southern African climate variability, and provide an explanation of why model skill in simulating summertime inter-annual variability is so much higher than for the other seasons. In particular, it has been demonstrated that the inter-annual variability of the westerly wind regime is less predictable than inter-annual variability in the tropics. During the autumn and winter seasons, transient systems from the westerlies follow more equatorward tracks, causing reduced predictability over southern Africa. This effectively places a limit on seasonal forecast skill for these seasons. The radiative forcing experiments, aimed at improving seasonal forecast skill over southern Africa, yielded an important result – skill in simulating the inter-annual variability of summer circulation may be improved through the inclusion of Antarctic stratospheric ozone forcing in the model. This project is thereby the first to demonstrate that this form of Antarctic stratospheric radiative forcing (which is strongest in spring) reaches subtropical southern Africa in December. The important practical implication of this finding is that rainfall and streamflow forecasts of summer rainfall over South Africa can now be performed more skilfully. Moreover, the dynamic-circulation mechanism through which this forcing mechanism reaches South Africa has been revealed by the project. Finally, the project findings indicate that under low and medium mitigation, the poleward displacement of the westerly winds under climate change (which is a result of the enhanced greenhouse effect and depleted stratospheric ozone) will prevail, despite the recovery of ozone concentrations. This implies that it is plausible for the southern African region, and in particular the southwestern Cape, to become drier under climate change.

Cost: R1 008 100
Term: 2012-2015

Using satellite data to identify and track convection over southern Africa

South African Weather Service; EUMETSAT

No. 2235

The science of nowcasting anticipates the weather events in the next few hours. These weather events can include heavy rainfall, strong wind, hail and/or tornadoes, and the climate authority such as the SAWS should issue the weather warning to various sectors of society to prepare for these events when they occur. While radar systems should provide the most useful information about the intensity, movement and characteristics of severe weather events, these data sources are expensive to obtain and require extensive maintenance. Usually, these radar systems do not provide coverage of the entire country and this leaves gaps between radars. The geostationary Meteosat Second Generation (MSG) satellite provides data coverage over all African countries and the operational use of satellite data as a possible solution for nowcasting of severe weather events in data-sparse regions is increasingly being considered by satellite users. To optimise the use of satellite data, the Nowcasting Satellite Application Facility (NWC SAF) has developed the 'Rapid Development Thunderstorms' (RDT) product. The aim of this product is to use data from satellites and a numerical weather prediction model to identify and track the more intense parts of thunderstorms. The software to generate this product can be downloaded from the NWC SAF website by any user. The purpose of this project was to implement this tool in South Africa.

Cost: R400 000
Term: 2013-2015

Dynamics of climate variability over the all-year rainfall region of South Africa

ARC (Institute for Soil, Climate & Water); CSIR

No. 2257

Climatologically, the all-year rainfall region along the Cape south coast is unique in the sense that it lacks the pronounced seasonality observed over the remainder of South Africa. Of the 21 water source areas over South Africa 4 are located within this region. Despite the importance of precipitation contributing to run-off and subsequent inflows into reservoirs, the contribution to rainfall by synoptic-scale weather systems and the understanding of interannual rainfall variability in this region is not well understood. This research addresses this knowledge gap as well as analysis of the association between the synoptic types and streamflow. The analysis revealed that ridging high pressure systems contribute most to the mean annual rainfall (46%), followed by tropical-temperate troughs (28%) and cut-off lows (COLs). COLs, co-occurring with ridging high pressure systems and tropical-temperate troughs that contribute to16% of the mean annual rainfall. COLs are also linked to interannual variability of seasonal rainfall, despite their infrequent occurrence. The single synoptic type associated with the largest contribution to mean annual streamflow is the strong ridging high pressure system. Half of this contribution is associated with COLs.

Cost: R312 000
Term: 2013-2015

Pinpointing human infectious disease risks and climate vulnerability: An integrative approach using cholera as a model

CSIR; Tshwane University of Technology

No. 2147

Two different, but related, research topics were investigated within the context of climate change and climate variability, namely: (i) to develop an early warning system for cholera outbreaks in delineated high-risk areas in South Africa and, (ii) to provide anticipatory adaptation options for drinking water infrastructure in the form of a booklet or guide aimed at vulnerable communities. Mathematical and modelling techniques were used for the analysis of cholera case data in conjunction with environmental factors and changes driven by climate events, locally, regionally and globally. The aim was to prove the cause-effect relationships between environmental changes and the cholera disease. However, due to the complexity of cholera ecology, it was not possible to elucidate true cause and effect mechanisms. Instead, mathematical and modelling techniques were used to elucidate correlation analyses using the main drivers of outbreaks, namely, accumulated amount of rainfall and the area affected; magnitude, duration, spatial extent and severity of floods; rainfall climatology; ENSO events and access to water and sanitation. The results indicated that the northern, north-eastern and eastern parts of South Africa and especially the Limpopo, Mpumalanga, KwaZulu-Natal and Eastern Cape provinces could be at risk of cholera outbreaks. The analyses resulted in a preliminary model based on correlations only. Further development and implementation of an early warning system for cholera needs to incorporate the following:

- Monitoring water bodies, point sources for the presence of toxigenic *V. cholera* and communicating the cholera situation in neighbouring countries continuously
- The incorporation of landscape topography, water pathways, socio-economic factors, water and sanitation infrastructure, road and medical infrastructure and human vulnerability
- In-depth investigation of all factors, cholera case data, environmental factors, including climate factors and human-related data at different spatial and temporal scales.

In the assessment of the vulnerability of both the community (Ga-Manoke in the Sekhukhune District, Limpopo.) and their current water infrastructure for sustainability of drinking water during future climate conditions, it was indicated that due to the community's exposure to poor service delivery, untreated water and communication, the community was indeed vulnerable. The study aimed to increase climate awareness and propose easily achievable improvements in water infrastructure in anticipation of climate hazards. From the interaction, there was a development of a guidebook (based on the case study) aimed at the community, its leadership and the municipality, for increasing the community's' resilience in terms of sustained drinking water provision.

Cost: R1 500 000
Term: 2012-2015

Water-energy nexus in the context of climate change: investigating trade-offs between water use efficiency and renewable energy options for South Africa

University of Cape Town; Pegasys Strategy and Development (Pty) Ltd

No. 2239

Water is a major driver of social and economic development for any nation. Nevertheless, access to fresh and adequate water is limited in many parts of the world, particularly in developing countries. As an arid and developing country, South Africa is faced with water resource challenges, such as issues of water shortage and quality. There is also a mounting pressure on the limited water resources due to economic and population growth, which will be exacerbated by the onset of climate change. It is perceived that the energy sector is one of the main contributors to water quality and high water use, through the burning of fossil fuels (coal, oil and gas), the discharge of poorly-treated wastewater, and the emission of greenhouse gases that cause climate change. SA has abundant reserves of coal, and coal-fired thermal power plants currently generate most of the electricity. In addition, fossil fuels are getting depleted, thereby decreasing energy security. Moreover, the demand for energy is also increasing. Consequently, there is a need to transform the country's energy mix in order to minimise negative impacts on water resources and mitigate the harmful effects of climate change. In view of this, SA is making some policy and regulatory shifts, in line with international developments, to address these environmental challenges. Renewable energy is being promoted as one way of achieving sustainable energy provision in the country, with a target of 10 000 GWh of energy to come from various renewable resources by 2013. The Renewable Energy Feed-in Tariff (REFIT) was introduced in 2009 and later, in 2011, revised to the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) with a competitive bidding process. Under this programme, the power generated by the independent power producers is fed to the national grid through a power purchase agreement (PPA). Nevertheless, some issues require close scrutiny in order to understand the water requirements of renewable energy production in the country. Due to the large gap that exists between water supply and demand, trade-offs in water allocation amongst different users and energy resources are critical.

Cost: R1 500 000
Term: 2013-2016

Improvement of early preparedness and early warning systems for extreme climatic events

South African Weather Service; Pegram and Associates (Pty) Ltd; Department of Water and Sanitation

No. 2068

This project endeavoured to enhance the early warning system against flash floods in South Africa, which is based on the South African Flash Flood Guidance (SAFFG) system. The SAFFG system models, on an hourly basis, the likely hydrological response of small river basins to rainfall, as estimated in near-real-time by weather radar systems and the Meteosat weather satellite. The performance of the SAFFG system was investigated and

the problem areas identified. This led to the development of an enhanced satellite rainfall estimation algorithm to address the serious underestimation of stratiform rain in the Western Cape Province, by combining convective rainfall estimation from satellite with stratiform rainfall forecasts from the Unified Model. Experiments were also conducted to improve the radar-rainfall relationships. A comparison of the soil moisture modelling of SAFFG with the PyTopkapi model revealed some errors in the calibration that were addressed subsequently by the SAFFG developers. The lack of an outlook of potential flash floods beyond the next 6 hours was addressed by the development of an ensemble forecasting system based on a single deterministic model. Understanding user needs was also an important focus of the project. These user needs were determined through sessions with various municipal and provincial disaster management centres. This led to the development of various user-oriented products, such as a system to forecast the likely impact of a flash flood, and not only the occurrence of the flash flood, by linking the potential of flash floods from the SAFFG model with socioeconomic vulnerability indicators through an impact model. The study was concluded with recommendations related to the enhancement of the entire flash flood early warning system.

Cost: R753 000
Term: 2011-2014

Programme 5: New water and water security

Optimising fog water harvesting

UNISA; University of Pretoria; private consultant; Bourkes Industries; South African Weather Service

No. 2059

Fog water harvesting is recognised as being an unconventional source of water for communities living in water-scarce fog-prone areas. The aim of this project was to optimise fog water collection by conducting research to elucidate the physical and chemical complexities of fog and its formation; optimising the fog water collection process; and developing novel products that could be used to measure flow and increase the yield during windless conditions. Two experimental sites were selected, one in the mountains near Avontuur in the south-eastern Cape and the other in the vicinity of Lamberts Bay on the West Coast. Various designs and materials were tested for their efficacy; problems related to construction of the fog water collection systems that were encountered during previous projects were solved; chemical analyses of the water were conducted to determine potability of the water; the impact of the systems on the environmental was determined; and predictions were made of the effect of climate change on fog water harvesting potential given specific climate change scenarios.

Cost: R2 500 000
Term: 2011-2015

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Screening study to determine the distribution of common brominated flame retardants in water systems in Gauteng

Tshwane University of Technology; University of Pretoria; Department of Water and Sanitation; Rand Water

No. 2153

Many organic compounds that are released either deliberately or accidentally into the environment can cause contamination. One of the most recently recognised environmental contaminants is brominated flame retardants (BFRs). Pentabromodiphenyl and octabromodiphenyl ethers have been listed in Annex A of the Stockholm Convention for elimination by parties to the Convention. They have been listed because of their persistence and bioaccumulative and endocrine-disrupting characteristics. The objective of this study was to investigate the presence and concentration of common BFRs in water systems in Gauteng province. Data on these emerging environmental contaminants is extremely important as South Africa aims towards national implementation of the National Toxicology Monitoring Programme (NTMP). The aims of the project were achieved by systematic planning (site identification and mapping, sample collection), application and validation of tested methods to determine the presence of BDEs in water system. Samples were collected from different catchments: Jukskei; Upper Klip; Riet Klip; Lower Klip; Vaal and Marico/Crocodile. Summer and winter samples were collected from the aforementioned sites. For groundwater, only 1 water sample per site was collected from the following sites Wonderboom Park, Eastling and Doorandjie. Landfill samples were collected from Hatherly, Soshanguve, Garstkloof, Onderstepoort, Chloorkop and Robinson deep landfill sites in winter and summer. With respect to wetlands, samples were collected from Bullfrog, Klip River wetland, Rietvlei, and Karlspruit for winter and from Soshanguve for summer. Fish samples were collected from the Vaal River. Despite the use and validation of the test methods, BDEs were generally not detected in water samples, but were detected in leachate and sediment samples. BDEs were detected in sediment samples collected in winter and summer from the Jukskei and Vaal Rivers and winter levels were significantly higher. Levels of BDE in landfill sediment samples were significantly higher than in leachate and unlined landfill sites showed higher BDE levels than lined landfill sites, most likely due to slow adsorption by soil in the former compared to a faster adsorption by geomembrane in the latter.

Cost: R900 000
Term: 2012-2016

Polycyclic aromatic hydrocarbons (PAHs) in the aquatic ecosystems of Soweto/Lenasia

North-West University (Potchefstroom); CSIR; National Metrology Institute of South Africa

No. 2242

This project looked at the presence/occurrence of PAHs in the Lenasia area with the focus on human health risk. Presence in fish and in bird eggs was assessed in order to extrapolate the risk to human health. Due to the nature of PAHs as byproducts of combustion, it was clear that the water resource as a medium does not hold much of the

total PAHs; higher levels occur in the sediment though as a result of deposition. But the highest risk to human health is from the daily breathing in of fumes in township areas where combustion of plastics and other materials is rife.

Cost: R375 000
Term: 2013-2016

Programme 2: Water quality modelling

Development and application of a simple South African water quality model for management of rivers and reservoirs under current and future development and climate change scenarios

Rhodes University (Institute for Water Research); Amatola Water

No. 2237

The aims of this project were:

- The construction of a water quality systems assessment model (WQSAM) to work in conjunction with both the WReMP or WRYM yield models and the Pitman model, to simulate the frequency of certain water quality concentration thresholds being exceeded, using predominantly available observed data, and a simplified conceptual framework
- Investigation of freely available remote-sensing data for parameterization and calibration of WQSAM
- The application of WQSAM to various catchments in South Africa, for comparison of model simulations to historical data, so as to assess the model's performance
- The assessment of various future development and climate change scenarios using WQSAM within the case study catchments, so as to assess the possible future impacts of development and climate change on water quality, and for comparison with results from previous studies

Cost: R500 582
Term: 2013-2015

A feasibility evaluation of the total maximum daily (pollutant) load (TMDL) approach for managing eutrophication in South African dams

DH Environmental Consulting cc

No. 2245

This project undertook a feasibility evaluation of the TMDL protocol in order to determine (a) those aspects thereof that can be used and supported by existing skills and information, and (b) the immediate skills and information needs that require development in order to effectively utilize the protocol or a variant thereof. The TMDL protocol is an American system that used to determine the maximum allowable load of pollutant that is acceptable in the effluent so that it does not impact on the downstream water quality. The study used a number of existing models and this indicated that firstly the requirement for regular monitoring and data management is essential as the model used is data intensive. The models were also not specific to the South African context and thus the development of local models is essential as well as developing the local coefficients that are used in the models. In terms of the skills, it is indicated that the poor development of limnology skills is a concern.

Cost: R638 250
Term: 2013-2015

System for patching river and reservoir water quality data

Umfula Wempilo Consulting; Hydrosol Consulting (Pty) Ltd

No. 2327

This project developed a method that enables the patching of water quality data at a station, followed by use of the patched data to extrapolate water quality data. This process is important as the number of monitoring stations is reducing and the frequency of monitoring cannot be guaranteed. The results of this project can assist the Department of Water and Sanitation to obtain a full dataset that can be used for reporting purposes and also to potentially predict future water quality.

Cost: R986 850
Term: 2014-2016

Programme 3: Impacts on and of water quality

Microbial pathogens in water resource sediments: their dynamics, risks and management

CSIR; Tshwane University of Technology; Eon Consulting; University of Cape Town

No. 2169

The aims of this project were 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

Cost: R1 300 000
Term: 2012-2015

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

The hydrogeology of Groundwater Region 65: Northern Zululand Coastal Plain

North-West University (Potchefstroom); University of KwaZulu-Natal (Westville)

No. 2251

The Zululand Coastal Plain (ZCP) is situated along the northeastern coastline of KwaZulu-Natal and is the largest primary aquifer in South Africa. Groundwater-dependent ecosystems are a common feature. The primary coastal aquifer spans an area of 6 000 km^2 and comprises Cretaceous age arenaceous formations which developed during aggression of the warm Indian Ocean and

subsequent Cenzoic unconsolidated deposits which are the product of multiple episodes of sea-level regression. A dual aquifer system comprising the shallow and deep aquifer occurs in the ZCP. Both aquifers are of primary porosity; however, they have distinct hydrogeological properties. The shallow aquifer of Cenzoic age is laterally extensive primarily along the eastern and southern regions of the study area and consists of fine grain sand of the Kwambonambi Formation. The aquifer is intercepted between 1 to 6 mbgl and is underlain by the clayey Kosi Bay and Port Dunford formations. Groundwater recharges several pans, lakes and shallow swamps. Borehole yields are low on account of the low transmissivity and are generally at 0.3 L/s; hence they are widely utilised for domestic purposes in the rural communities. The karst weathered shelly coquina and calcaernites of the Cretaceous deposits comprise the deeper aquifer. The aquifer which is irregularly distributed is generally intercepted at depths of 30 to 40 mbgl. Typical borehole yields range from 15 to 25 L/s.

Cost: R550 000
Term: 2013-2015

Characterising the chemical composition of deep and shallow groundwater in an area considered for shale-gas exploration in the Main Karoo Basin

Groundwater Africa; Stellenbosch University; Duke University; IGS

No. 2254

A major concern regarding shale gas development is that deep borehole drilling and the hydraulic fracturing process (or fracking) may create conduits through which deep-seated groundwater could migrate to shallow aquifers. If this deep groundwater is of poor quality, and if shale gas development does facilitate upward migration of deep waters, then it is possible that poor-quality deep groundwater may blend with shallow Karoo groundwater currently used for water supplies. In some areas; the deep groundwater may even issue at the surface via leaking shale gas boreholes should they lose their integrity. This concern is primarily a long-term one. The overall aims of the project were: (i) In selected areas in the Main Karoo Basin where shale gas exploration is envisaged, characterise shallow (cold) and deep (warm) groundwater by analysing the waters (borehole and spring) for chemistry including trace elements, heavy metals, rare earth elements, isotopes, radioactivity and, where possible, dissolved gases (e.g. methane and helium); (ii) identify specific determinants that distinguish shallow from deep groundwater and whether specific areas associated with shallow water samples contain traces of deep groundwater; (iii) for regulatory purposes, develop a list of determinants that should be analysed in both shallow and deep boreholes in future shale gas exploration and development areas.

Of the 20 assessed sites, 7 could be confidently classified as deep or warm groundwater, whilst 8 could be confidently classified as shallow or cold groundwater. The remaining 5 sites were classified as mixed. This study set out to identify indicators of deep groundwater flow in the Main Karoo Basin. It was not possible to obtain groundwater samples from the deep-seated shales that are being considered for shale gas exploration and development because no suitable deep boreholes exist. Instead; samples from warm springs and two deep boreholes that pass through the shales were obtained as the best approximation of deep-seated groundwaters in

the Karoo at this stage. Deep and shallow groundwaters were characterised and determinants were identified to differentiate these waters. While this project noted fairly consistent geochemical patterns throughout the vast area of the Karoo, it must be stressed that the analyses, conclusions and recommendations presented pertain to a relatively small sample number of water and gas samples derived from sources of unknown depths.

Cost: R1 000 000
Term: 2013-2015

Impact of underground coal gasification on the groundwater environment

Digby Wells & Associates; Eskom; Department of Water and Sanitation

No. 2331

UCG is a process whereby coal is gasified in-situ in non-mined coal seams using the injection of oxidants and bringing the product gas (referred to as syngas) to the surface through production boreholes drilled from surface. Although UCG offers important environmental and economic advantages when compared to more conventional methods of coal recovery, groundwater contamination is the most serious risk associated with it. This study was conducted at a desktop level by reviewing hydrogeological conceptual understanding of the Karoo aquifers and the environmental lessons learnt from countries that have implemented UCG. UCG trials and projects have been conducted worldwide since the mid-20th century. In many countries, however, it is a new coal extraction technique which is on the verge of large-scale commercial development. It is still at its early stages especially in South Africa, with only Eskom conducting a research-scale UCG development on the Majuba Coalfield. The Majuba results concluded that UCG offers an opportunity for expanding South Africa's mineable coal reserve by extracting coal previously disregarded as being un-mineable.

Cost: R242 862
Term: 2014-2015

Programme 2: Land-water linkages

Planning for adaptation: Applying scientific climate change projections to local social realities

University of Cape Town; Environmental Monitoring Group; University of KwaZulu-Natal (Pietermaritzburg)

No. 2152

Even if greenhouse emissions are radically decreased, poor people in the developing world will still feel the impacts of climate change on their lives and livelihoods. While this may be manifested in drought and floods, rising temperatures and shifting weather patterns will also affect the availability and quality of basic water supply. World-class hydrological studies have been conducted that model the various impacts of climate change on South Africa's catchments. These studies are used to inform national, and possibly catchment level, planning, yet poor communities have largely been absent from information and planning processes.

While macro-plans are no doubt important, community-level action planning is essential in order to develop relevant and implementable solutions. This project bridged the gap between science and society to support community-based adaptation. Hydrologists and climate modellers worked with NGO practitioners to develop, downscale and 'translate' scientific projections, based on livelihood and vulnerability information created jointly with pilot communities. NGOs ran community workshops that were specifically tailored around building awareness of climate change and the need for community-based adaptation; exchanging knowledge with communities, including presenting the downscaled climate model projections for their areas; and supporting communities to develop local action plans. During 2013 and 2014, NGOs conducted either two or three full-day workshops with community groups in four areas: KwaNgcolosi and Nxamalala in the uMngeni River catchment in KwaZulu-Natal (Umphilo waManzi); and Goedverwacht, in the Berg River catchment and Herbertsdale in the Breede River catchment in the Western Cape (Environmental Monitoring Group). These areas were chosen based on criteria developed by the NGOs and hydrological modellers, and included: local level organisation and leadership, presence of an NGO or other support structures, climate change signal, and availability of hydrological data at the hydrologically relevant scale.

Cost: R1 100 000
Term: 2012-2015

Groundwater yield-reliability analysis and operating rules for rural areas

University of Venda Department of Water and Sanitation; University of the Witwatersrand

No. 2157

Water supply systems that obtain water from groundwater reservoirs require operating rules/strategies to regulate the competing water uses, ensure the beneficial use of water and also account for the groundwater Reserve. Management strategies are also required to address the unique characteristics and roles of groundwater. Groundwater yield–reliability analysis is required when deriving operating rules. Operating rules provide statements about the water to be allocated from a given resource at a given time. The study concluded that since groundwater can meet domestic demand at the highest recommended reliability level, its development for use or integration with run-of-river (ROR) and rainwater would improve on the livelihoods of residents of Siloam Village. An earlier study had shown that run-of-river (ROR) and rainwater improves yield and reliability up to 1:25 (96%) for a period of 9 months, which is below the recommended level of assurance of supply of 1:100 (99%).

Cost: R700 000
Term: 2012-2015

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Natural resource governance system in South Africa

Pegasys Strategy and Development (Pty) Ltd

No. 2161

Project aims:

- 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' (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

Institutional arrangements for implementing water equity mechanisms in South Africa

Prime Africa Consultants (previously CIC International)

No. 2255

Project aims:

- Investigate the potential benefits of two water equity enforcing mechanisms: domestic water supply and the General Authorisation (Government Gazette No. 20526 8 October 1999)
- Design the institutional requirements for implementing these water equity enforcing mechanisms
- Determine the costs and risks to the fiscus of these institutional requirements
- Develop a case (in National Treasury format) for implementing these mechanisms.

Estimated cost: R 1 162 600
Expected term: 2013-2016

Lessons learnt from the establishment of catchment management agencies in South Africa

University of KwaZulu-Natal – Centre for Water Resources Research (CWRR)

No. 2320

Project aims:

- Tell the story of the establishment and evolution of Breede-Overberg CMA and Inkomati CMA to date
- Identify the processes that either had positive or negative impacts on CMA establishment
- Determine how stakeholders perceive the successes and strengths of the CMA establishment process
- Examine causal links between elements of the establishment process and its successes and failures
- Determine who acts and what the consequences are
- Identify new opportunities and challenges regarding future CMA establishment

Estimated cost: R1 000 000
Expected term: 2014-2016

When and under what conditions should a CMA become a responsible authority?

Crossflow Consulting (Pty) Ltd

No. 2334

Project aims:

- To define the powers, duties and functions that are required for CMAs to manage, monitor, conserve and protect water resources and to implement catchment management strategies
- To assess the risks, including concerns related to feasibility (financial and technical) and desirability (legally and operationally) for CMAs to be become Responsible Authorities
- To define the specific requirements for a CMA to undertake certain powers, duties and functions and for the regulation of these functions
- To develop a road map for CMAs to be become Responsible Authorities

Estimated cost: R1 000 000
Expected term: 2014-2016

Water governance of groundwater and surface water resources in South Africa

Umvoto Africa

No. 2332

Project aims:

- Review the lessons learnt from the Global Groundwater Governance Study and compare it to the South African situation
- Apply the methodologies developed through surface water and groundwater governance studies in previous WRC reports to selected catchments
- Develop a framework to improve groundwater and surface water governance within the existing legal and institutional arrangements that span all the relevant institutions
- Test the framework with realistic case studies
- Develop an action plan to enhance uptake of the framework

Estimated cost: R1 000 000
Expected term: 2014-2016

Catchment management fora: the evolving priority in effecting subsidiarity principles in water management

Pegasys Strategy and Consulting; AWARD; North-West University (Vaal Triangle Campus)

No. 2411

Project aims:

- To synthesize existing information on forums' histories in South Africa, against the background of international practice, with a focus on the agency of active citizens
- To address issues of redress and equity through understanding the reasons why current participation in forums is not representative, what the obstacles to participation are, and how these can be removed
- To bring current CMF participants and potential new CMF participants together in regional and in one national workshop, to co-create a vision to revitalize forums, and attract citizens that will make the forums truly representative of all water interests
- To explore the functions that can be delegated to CMFs, including citizens' monitoring for compliance, and awareness raising in schools and communities
- To develop recommendations on how CMFs can function better, how they can be supported by DEPARTMENT OF WATER AND SANITATION and CMAs, and how they fit into the catchment management architecture
- To share the knowledge developed in this process

Estimated cost: R56 000
Expected term: 2014-2015

Assessment of implementation of all national water-related policies and the development of the framework for monitoring the extent of the implementation of the NWA

Prime Africa Consultants cc

No. 2417

Project aims:

- To conduct a comprehensive performance assessment of the nature and extent of implementation of the water policies and the NWA in South Africa. This performance assessment will include assessment of progress in implementation of water polices and the NWA against policy/legislative objectives, targets and recommendations
- To identify the gaps and lessons learnt from the implementation of these water policies and the NWA
- To inform the amalgamating of the NWP and NWA, based on a consultative process of assessment
- To develop a framework for the assessment of the resources required for the implementation of the amended/new and amalgamated NWP and NWA
- To apply the framework to formulate different resource dimensions required to implement, and monitor progress of, the reviewed/amalgamated NWP and NWA
- To establish the means of determining the obstacles and/or contradictions that may hamper implementation of the NWA and NWP.
- Using scenarios, identify the kinds of investments that are needed

Estimated cost: R1 000 000
Expected term: 2015-2016

Programme 2: Compliance and enforcement

Citizen monitoring of the National Water Resource Strategy 2

Environmental Monitoring Group

No. 2313

Project aims:

- To pilot, test and improve an approach that empowers community-based and other civil society groups to participate in local water governance, using forms of knowledge and analysis appropriate to their context and experience, through monitoring and engaging on key issues from the NWRS2
- To use the NWRS2 as a case study to contribute to an understanding of how South African water policy is developed and implemented, and what role civil society can play in these processes
- To test the application of social learning approaches to capacity building in the water sector
- To strengthen community-based organisations and networks within the water sector through peer support and social learning
- To contribute to the effective and just implementation of the NWRS2

Estimated cost: R1 764 300
Expected term: 2014-2017

Programme 3: Pricing and financing WRM

Approaches for emerging farmer participation in water resource management: The case of the Breede-Overberg Catchment Management Agency (BOCMA), Western Cape

Cape Peninsula University of Technology

No. 2310

Project aims:

- Review progress in accessing water resources by emerging farmers in two selected areas in the Breede-Overberg Catchment Management Agency
- Explore the role and challenges faced by emerging farmers in participating in water user associations
- Explore opportunities for engaging emerging farmers to participate in water user associations and water allocation processes
- Develop a general approach for engaging emerging farmers to participate in water user associations in the Western Cape (and South Africa)

Estimated cost: R1 303 000
Expected term: 2014-2017

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 3: Water resource planning and infrastructure

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

Programme 4: Climate change and water resources

Managing limits in skill for seasonal climate forecasting

University of Cape Town

No. 2249

Project aims:

- Identify the signal to noise ratio over southern Africa using observations and GCM datasets in response to the forcing of global modes of variability
- Identify the spatial and temporal time scales of robust regional response to global modes of variability
- Develop a new methodological approach to explore the climate system on seasonal and sub-seasonal timescales using the phase space of the daily evolution weather states
- The integration of regional responses using a hydrological model forced by daily (or finer) meteorological variables (temperature, humidity, wind speed, radiation and precipitation) derived from regional climate signals
- An understanding of the theoretical limits to predictability from seasonal forecast models, utilizing ensemble-based prediction techniques in the perfect model scenario
- Explore which physical parameters of the regional climate system best reflect a deterministic response signal
- Test emergent understanding of how models may be developed to improve forecasts

Estimated cost: R2 025 640
Expected term: 2013-2017

Quantification of uncertainty in weather and climate prediction and its effective communication for better decision making

CSIR

No. 2325

Project aims:

- To quantify (through estimation of the reliability of weather and climate forecasts) and reduce (through ultrahigh horizontal resolution simulations for cloud-resolving purposes) the uncertainties associated with predicting and projecting future weather and climate

variability as well as change over the southern African region, with an emphasis on extreme events
- To optimize the configuration of the variable-resolution atmospheric model CCAM, applied at various time scales for equivalent horizontal resolutions and domains, as part of the endeavour to build an Earth System Model (ESM), since the generation of simulations on these time scales provides a test-bed for the atmospheric model that will form an integral part of the ESM
- To develop plausible scenarios of future changes in the attributes of extreme weather events over the continent, of sufficient reliability to be actionable
- To construct large ensembles of predictions/projections at the short-range, medium-range, long-range and decadal time scales over southern Africa, by considering initialization techniques, vertical resolutions, cloud schemes, and dynamical land-surface coupling in the model

Estimated cost: R600 000
Expected term: 2014-2016

Open water evaporation measurement using micrometeorological methods

University of KwaZulu-Natal (Pietermaritzburg)
No. 2335

Project aims:
- Review studies conducted and approaches followed internationally, aimed at estimating open water evaporation
- Define the theoretical framework for the estimation of open water evaporation using sound physical procedures
- Define the theoretical framework for the real-time estimation of evaporation using the surface renewal and temperature variance methods and their application to open water
- Define the theoretical framework for applying the MOST method for determining sensible and latent energy fluxes and determine the accuracy of the air temperature and water vapour pressure sensors
- Application of sound open water evaporation procedures for obtaining open water evaporation
- Field application of all methods for obtaining open water evaporation

Estimated cost: R1 100 000
Expected term: 2014-2016

Towards gender-sensitive strategies for responding to challenges posed by climate-related impacts

University of the Western Cape
No. 2314

Project aims:
- Investigate enabling factors and constraints for women's participation in decision-making processes within the water sector
- Undertake a pilot study on vulnerability assessment of rural women under changing climatic conditions
- Investigate the challenges that women encounter around water security
- Evaluate the extent to which policy frameworks and strategies that address access to resources are gender sensitive
- Identify barriers to women's access to resources such

as land, water and finance and recommend how these could be addressed
- Recommendation and institutionalisation of good practice in policy practice and design a framework for mainstreaming gender into climate change adaptation

Estimated cost: R1 200 000
Expected term: 2014-2017

Future climate change impacts on flood and drought hazards in South Africa for planning and decision-making

South African Weather Service

No. 2247

Project aims:
- Evaluate the performance of the combined GCM/downscaling technique/hydrological model's skill in simulating observed droughts and floods in the present/control climate
- Analyse changes in drought and flood hazards in South Africa by examining extreme discharge levels simulated by a hydrological model
- Investigate the main physical mechanisms likely to result in changes in the hazards found above
- Compare the uncertainty sources for climate change impacts on future droughts and floods
- Develop information for decision makers on future drought and flood hazards that is insensitive to the various sources of uncertainty involved in the modelling process

Estimated cost: R1 113 000
Expected term: 2013-2017

Regionally-extensive droughts and climate change in Southern Africa: mechanisms, model reliability and projections

University of Cape Town

No. 2317

Project aims:
- Incorporate evapotranspiration (ET) into drought indices to obtain a better characterisation of agricultural and hydrological droughts over Southern Africa
- Understand the mechanisms by which remote and local forcing of drought are translated into surface moisture deficits (P-ET)
- Evaluate climate model's abilities to represent regionally extensive droughts and the associated mechanisms
- Understand the potential impacts of climate change on regionally-extensive droughts in Southern Africa

Estimated cost: R1 150 000
Expected term: 2014-2017

Soil moisture-climate interactions under climate change: Implications for droughts, heat waves and desertification over Southern Africa

South African Weather Service

No. 2309

Project aims:
- Identify CMIP5 simulated hotspots of soil moisture–climate interactions in the historical runs
- Investigate future changes in soil moisture regimes and the possible impacts on the locations of the hotspots identified

- Investigate the contribution of changes in soil moisture to the accelerated warming rates over south-western Africa (Northern Cape, Namibia and Botswana)
- Understand the implication of the higher warming rates for the frequency and intensity of 21st Century heat waves
- Establish the effects of changes in soil moisture regimes on the pattern and intensity of meteorological droughts
- Investigate the likely change in the spatial extent of semi-arid regions

Estimated cost: R1 080 000
Expected term: 2014-2017

Validation of the variables (evaporation and soil moisture) in hydrometeorological models: Phase II, application of cosmic ray probes for soil water measurement

University of KwaZulu-Natal – Centre for Water Resources Research (CWRR)

No. 2323

Project aims:

- 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 and K5/2066)
- Provide accurate field and satellite estimates of the variables (ET and SM) for the calibration of hydrometeorological models
- Evaluate the spatial variability of SM at catchment scale; test the suitability of the Cosmic Ray Probe for providing spatial estimates of soil moisture at the same scale as the remote-sensing products from HYLARSMET

Estimated cost: R1 000 000
Expected term: 2014-2017

Programme 5: New water and water security

Sustainability indicators and decision framework for sustainable groundwater use

Helen Seyler Consulting

No. 2311

Project aims:

- To provide an understandable and accessible description of the equilibrium approach to sustainable groundwater use
- To promote use of the equilibrium approach for sustainable management of groundwater use, especially for moderately and highly used aquifers
- To develop a decision framework tool to guide a user through the adaptive management cycle of managing groundwater use sustainably, especially for moderately and highly used aquifers
- To develop sustainability indicators that can be used to qualitatively and quantitatively manage groundwater use

Estimated cost: R700 000
Expected term: 2014-2017

EXSMET: Exporting PyTOPKAPI and HYLARSMET over SADC including RSA with extended spatial and computational capacity of soil moisture and evapotranspiration for flood and drought monitoring

Pegram and Associates (Pty) Ltd

No. 2312

Project aims:

- To ascertain what rainfall data are available in the SADC countries outside our borders and perform checks on their suitability for modelling
- To obtain suitable ground cover and soil maps over the whole SADC region (e.g. FAO and others), for comparison with those already available in SA
- To exploit the sensitivity calculations performed on the SA dataset under HYLARSMET
- To determine the best way to compare FAO datasets with our SA sets of ground-based data
- To determine if there are better alternative rainfall inputs to TRMM, for near real-time precipitation data input; if not, exploit bias adjustment of the TRMM product
- To exploit the soil moisture estimates of the European Space Agency's SMOS mission when they are ready for using in model inter-comparisons
- To determine how best to cope with the uncertainties associated with input parameters and forcing variables (TRMM in particular) when computing ensembles of historical and forecast data streams
- To devise means of increasing computing capacity and the speed of calculations by improving key parts of the code and employing parallel (or high performance) computing power
- To determine the best ways of cold-starting calculations (model initialization) for both gauged and ungauged catchments

Estimated cost: R1 980 000
Expected term: 2014-2018

Finding 'new' water in an 'old' catchment: the case of the Heuningnes Catchment, Breede-Overberg Water Management Area

University of the Western Cape

No. 2324

Project aims:

- To determine the contributions of sub-catchments of the Heuningnes River to inflows into the Soetendalsvlei and Heuningnes Estuary
- To establish the effects of land uses and water uses on quantity and quality of inflows into the Soetendalsvlei and Heuningnes Estuary
- To establish the extent to which marshes occurring along stretches of the Nuwejaars River and tributaries modify inflows into the Soetendalsvlei
- To determine how river inflows, the interactions between surface water and groundwater affect the water balance dynamics of Soetendalsvlei, and outflows into the Heuningnes Estuary

Estimated cost: R1 400 000
Expected term: 2014-2017

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Encouraging citizens' water quality management through subcatchment forums

Mvula Trust

No. 2151

Project aims:

- 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

Water resources management in South Africa: towards a new paradigm

Rhodes University

No. 2248

Project aims:

- To write a starter discussion document that elaborates the framework and process for the project
- To build a transdisciplinary team to undertake the project
- To develop a systems-based project design that integrates the case study focus areas (resource protection, eutrophication and microbial pollution); place-based case studies at different scales; and overarching concepts including complexity, complex social ecological systems, transdisciplinarity, resilience, social learning and strategic adaptive management
- To develop, workshop and finalise the detailed aims, methods, and outcomes at each site, for each case focus, and the whole project
- To undertake and clearly link the theoretical, conceptual framework to a specific set of methodologies, to lay a foundation for the development of robust transdisciplinary scholarship and practice; and to explore a richer understanding of 'integration'
- To provide a rich and clear understanding of the 'new paradigm' together with inherent implications (intended and unintended consequences)
- To develop a set of guiding principles for IWRM in South Africa
- To undertake relevant research in place-based case study areas in respect of each case focus area (eutrophication, microbial pollution, water resource protection)
- To have facilitated the development of appropriate software and data curation to support 'new paradigm' thinking and practice
- To have proposed and selectively practised the 'new paradigm' of water resource management in South Africa
- To have contributed to the scholarship and practice

of transdisciplinarity, particularly in the linked development of concept, theory and method
- To recommend a principle-based and adaptive contribution to the ongoing review and writing of the National Water Resource Strategy

Estimated cost: R5 000 000
Expected term: 2013-2017

Programme 2: Water quality modelling

Simulation of pollutant transport, sediment concentration and nutrient budget for uMngeni river

University of KwaZulu-Natal (Howard College Campus)

No. 2328

Project aims:
- To analyse the existing water quality data
- To investigate the main drivers for the river water quality issues
- To understand pollutant transport processes for the river environment under various flow conditions
- To develop a mathematical hybrid model for simulation of pollutant concentrations with sediment flux and nutrient budget
- To test and calibrate the developed model using the dataset
- To develop a user-friendly software package

Estimated cost: R667 000
Expected term: 2014-2017

Programme 3: Impacts on and of water quality

Combined effect of urbanisation, industrialisation and population growth on water quality of the Palmiet River and its tributaries in the Overberg West sub-catchment of the Breede Water Management Area: An integrated catchment risk assessment

Cape Peninsula University of Technology

No. 2329

Project aims:
- The overall aim of the study is to conduct an integrated catchment risk assessment to determine the impacts of the combined effects of urbanisation, industrialisation and population growth on water quality in the Palmiet River and its tributaries in the Overberg West sub-catchment of the Breede Water Management Area
- Conduct an environmental hazard assessment to identify and quantify the sources of selected micro-pollutants (organic waste, nutrients and pathogens) in the sub-catchment; this assessment will culminate in a conceptual site model for the Overberg West sub-catchment
- Characterise the hazards by gathering, generating and evaluating data on the pollutants and conclude on their toxicological effect and environmental fate; this will allow for the evaluation of the nature of the adverse effects associated with biological, chemical and physical agents

- Develop an integrated fate and transport model by Identifying the principal/dominant flow pathways, determining the dominant hydro-chemical processes controlling the fate and transport of the contaminants, and the potential for polluting
- Develop a quantitative microbial risk assessment and chemical risk assessment model to predict and evaluate the risks emanating from contamination and pollution
- Determine best management options and translate these into management and policy recommendations

Estimated cost: R850 000
Expected term: 2014-2017

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

The selection and validation of sediment toxicity test methods to be included in the National Toxicity Monitoring Programme

Golder Associates Research Laboratory

No. 2160

Project aims:

- 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 vadidation documentation
- Training and implementation of the method

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

Groundwater remediation technologies manual for South Africa – a theoretical treatise and practical guide

Hydro Aqua Earth

No. 2167

Project aims:

- 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

Guidelines for the delineation of protection zones in a complex aquifer setting

GCS; University of the Western Cape

No. 2288

Project aims:

- Build on DWA project by including international best practice regarding complex aquifer settings
- Evaluate fractured rock aquifer data collection methodologies
- Develop initial guideline for complex aquifer systems
- Test initial guideline at Rawsonville TMG research site
- Investigate data needs and application of risk analysis modelling software
- Effect of seasonal variation on protection zones
- Minimum requirements to establish protection zones in complex aquifer settings
- Finalise guideline for protection zoning strategy in complex aquifer settings

Estimated cost: R510 000
Expected term: 2013-2014

Modelling studies and analytical methods for monitoring organic pollutants in selected surface water and treated water systems in Gauteng Province

University of Johannesburg

No. 2321

Project aims:

- To prepare a database of chlorinated organic compounds found in South Africa water systems. This database will include the factors that determine the levels of chlorinated organic compounds (COCs) in water
- Use the determined factors that influence the amounts of COCs to predict levels of COCs in a given water system
- To analyse real water samples so as to determine the levels of various COC pollutants in selected water systems found in Gauteng Province
- To develop a computer model that would predict the contamination level of COC pollutants in selected water systems found in the Gauteng Province
- To generate various predictions of organic pollutants using various water system scenarios. Compare the predicted levels with the analysed values.
- To determine the prediction efficiency of the model by testing real water samples through analysis for COCs and compare the experimental data with the predicted model values

Estimated cost: 2014-2017
Expected term: R665 000

Programme 2: Land-water linkages

Unconventional gas exploration and mining and its impact on South Africa's water resources

SLR Consulting (South Africa) (Pty) Ltd

No. 2322

Project aims:

- Update the WRC state-of-the-art report (KV294/11) to include all unconventional gas sources and other available reports focusing on among others, hydrogeology of areas where unconventional gas mining is being considered, water use, contamination and remediation

- Do a gap (and barrier) analysis of the technical, policy and regulatory requirements related to unconventional gas mining
- Perform a risk-based assessment of selected aquifers, recharge areas and surface water bodies to enable adequate protection of these systems
- Develop a water resource early warning monitoring system that could inform regulatory policies, strategies and responses
- Develop best-practice guidelines and regulatory responses based on a variety of approved and workshopped scenarios
- Develop the best-practice framework in a manner that accounts for the technical and socio-economic considerations

Estimated cost: R2 500 000
Expected term: 2014-2017

NEW PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Assessment of implementation of all national water-related policies and the development of the framework for monitoring the extent of the implementation of the NWA

Sustento Development Services cc; Prime Africa Consultants cc

No. 2417

Project aims:

- To conduct a comprehensive performance assessment of the nature and extent of implementation of the water policies and the National Water Act (NWA) in South Africa. This performance assessment will include assessment of progress with implementation of water polices and the NWA against policy/legislative objectives, targets and recommendations
- To identify the gaps and lessons learnt from the implementation of these water policies and the NWA
- To inform the amalgamation of the NWP and NWA, based on a consultative process of assessment
- To develop a framework for the assessment of the resources required for the implementation of the amended/new and amalgamated NWP and NWA
- To apply the framework to formulate different resource dimensions required to implement, and monitor progress of, the reviewed/amalgamated NWP and NWA
- To establish the means of determining the obstacles and/or contradictions that may hamper implementation of the NWA and NWP
- Using scenarios, identify the kind and quantum of investments that are needed to achieve the different scenarios, i.e., development of a business case for the scenarios

Estimated cost: R1 000 000
Expected term: 2015-2016

The path to successful water user associations in the NW dolomites

Jude Cobbing Consulting; Counterpoint Development; University of Pretoria

No. 2429

Project aims:

- To review available literature relating to water user associations (WUAs), especially in the North West (NW) Province, and provide a concise account of the current institutional situation with respect to the NW dolomite compartments. This includes both formal organisations collaborating to manage groundwater, as well as informal rules, mechanisms and other institutions.
- To provide an overview of the current economic activities in and relying on the two dolomite compartments focused on (Steenkoppies and Grootfontein) including the economic position of commercial agricultural activities. This overview will also provide a qualitative account of the potential costs of losing access to groundwater supplies in one or more compartments.
- To describe the legal and procedural/administrative milestones or challenges to establishing a WUA in a dolomite groundwater compartment (or series of compartments).
- To describe the practical bottlenecks to establishing a WUA, with particular emphasis on the Grootfontein compartment, and to suggest possible ways to improve the situation. This will take into account the strong possibility that such bottlenecks interact in unexpected ways.

Estimated cost: R335 000
Expected term: 2015-2016

Programme 3: Pricing and financing WRM

Towards sustainable economic development in water constrained catchments: tools to empower decision making

GreenCape; University of Cape Town

No. 2453

Project aims:

- To develop a guideline for a planning approach that recognizes the cyclic interdependency of economics and water resources
- To conduct an economic, social and environmental cost–benefit analysis (CBA) and cost-effective analysis (CEA) of economic developments and water resource interventions
- To build a spatial hydro-economic model (HEM) for use as a tool to manage regional allocations in constrained catchments, which can be customized for use in other regions/contexts
- To develop research products in close collaboration with decision-makers, and implement research outcomes to address current development challenges

Estimated cost: R2 059 672
Expected term: 2015-2018

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Implementation of Adaptive Operational Governance Dashboard (AOGD) for the Inkomati-Usuthu CMA

University of KwaZulu-Natal (Pietermaritzburg); DHI (SA); Hydrologic Consulting (Pty) Ltd; Jeffares & Green (Pty) Ltd; Inkomati-Usuthu Catchment Management Agency

No. 2418

Project aims:

- Conform operational setup, automation and information sharing needs of the AOGD
- Add the Technical & Economic components of STEEP to the AOGD
- Add the Social & Political components of STEEP to the AOGD
- Train ICMA Board and staff as well as key stakeholders on the use of the AOGD

Estimated cost: R1 788 000
Expected term: 2015-2017

Water accounts for South Africa

Prime Africa Consultants cc; United Nations Environment Programme; University of Pretoria

No. 2419

Project aims:

- Phase 1
  - Provide a methodological framework for the water accounts according to international best practices
  - Consultation through engagement with all relevant role-players
  - Create a framework, structure and knowledge base for these accounts to enable more frequent updates and potentially more detailed accounts in the future
- Phase 2
  - Provide a research document containing an overview of the methodology, water tables and water accounts that can be published in collaboration with Stats SA
  - Provide the water tables and water accounts in Excel to enable ease of use for integrated impact and policy analysis

Estimated cost: R1 800 000
Expected term: 2015-2017

Constructing a baseline of environmental, agricultural and socio-economic intersections for the Mzimvubu Water Project

University of Fort Hare; Rhodes University

No. 2433

The objective of this project is to construct and develop a detailed baseline database of environmental, agricultural and socio-economic aspects which might be influenced by the Mzimvubu Water Project. Specific aims and objectives include:

- To construct and develop a database of the water quality and streamflow regimes at representative sites in the Tsitsa River prior to the Mzimvubu Water Project
- To construct and develop a database of groundwater levels and quality at representative sites prior to the Mzimvubu Water Project

- To quantify suspended sediment loads in the Tsitsa River during selected flood events prior to the Mzimvubu Water Project
- To characterise stream geomorphology of the Tsitsa River below the Ntabelanga Dam up to the confluence with the Mzimvubu River prior to the Mzimvubu Water Project
- To construct a database of riparian vegetation at selected sites prior to the Mzimvubu Water Project

Estimated cost: R2 000 000
Expected term: 2015-2018

The impacts of commercial plantation forests on groundwater recharge and streamflow

CSIR

No. 2443

Project aims:

- To quantify the long-term (at least annual) water use of key commercial plantation forests, e.g. pine and eucalyptus species, and co-occurring indigenous vegetation in the catchment
- To monitor and compare the groundwater levels in the vicinity of the plantation forest and in the area occupied by the indigenous vegetation
- To identify the sources of water used by the plantation forests and to quantify the proportion of total water use that is derived from groundwater
- To quantify groundwater recharge variations between commercial forest and indigenous vegetation ecosystems using a suitable unsaturated zone model
- To extrapolate the results and findings to the quaternary catchment scale using a coupled groundwater–surface water model
- To validate remote-sensing products utilizing the data generated during this study

Estimated cost: R1 605 960
Expected term: 2015-2018

The hydrogeology of Groundwater Region 39

North-West University (Potchefstroom); University of KwaZulu-Natal (Westville)

No. 2456

Project aims:

- Analyse and present the related groundwater data in a concise manner
- Estimate how much water is available for use and how much is currently being used
- Quantify possible pollution sources and associated impacts
- Provide guidelines for the future development and management of groundwater resources
- Provide a document (standard format for the groundwater regions as set out by Vegter), a database and tools to assist in the management of groundwater resources within the study area

Estimated cost: R400 000
Expected term: 2015-2017

Programme 2: Surface water / groundwater hydrology

Sustainability of shallow groundwater utilization for small-holder irrigation in the Limpopo Province

CSIR; University of Limpopo

No. 2426

Project aims:

- To determine the extent of shallow groundwater in the area of the Mopani District
- To determine the sustainability of large-scale groundwater use in the Mopani District
- To investigate the environmental sustainability of irrigating selected alternative and indigenous crops on emerging farms
- To investigate the potential and quantify the effects of riparian vegetation strips in mitigating the impacts of agricultural activities on shallow groundwater

Estimated cost: R2 727 800
Expected term: 2015-2018

Optimising the use of updated and additional products from the Nowcasting Satellite Application Facility to improve the Rapidly Developing Thunderstorms and Convective Rainfall Rate products

South African Weather Service; EUMETSAT

No. 2430

Project aims:

- To use and test the latest version of the Nowcasting software (v2013) for the RDT and CRR products on a dedicated server at SAWS using information from the MSG satellite, and model input from the local version of the Unified Model
- To include lightning data from the South African Lightning Detection Network as auxiliary data to further enhance the accuracy of the products
- To transfer skills to forecasters from South Africa as well as southern Africa, in order to understand the improvements to the products and its usefulness (through training sessions and/or workshop presentations)
- To make the improved RDT and CRR products operationally available to all forecasters in SA as well as SADC via the Internet

Estimated cost: R250 000
Expected term: 2015-2017

Enhancement of the method to identify and delineate South Africa's water source areas ,water towers, with specific focus on mountain groundwater systems

CSIR; Dirk Versfeld cc; DELTA-H (Pty) Ltd

No. 2431

Project aims:

- Review and refine the understanding of the hydrological processes that lead to the generation of runoff and groundwater recharge in South Africa's water source areas, and especially in groundwater systems
- Develop an integrated method to identify and delineate Water Source Areas that include run-off generation and groundwater recharge
- Identify additional management/protection requirements for Water Source Areas

Estimated cost: R3 500 000
Expected term: 2015-2018

Resetting the baseline land cover against which streamflow reduction activities and the hydrological impacts of land use change are assessed

University of KwaZulu-Natal (Pietermaritzburg); SAEON

No. 2437

Project aims:

- To classify Mucina & Rutherford (2006) vegetation types into hydrologically relevant vegetation groups
- To estimate spatial baseline (natural) vegetation water use using remote sensing (SEBS)
- To derive vegetation and water use input parameters for each vegetation grouping for hydrological modelling
- Determine the hydrological response under the Mucina and Rutherford (2006) baseline
- Determine the potential implications of using Mucina and Rutherford (2006) as the baseline vegetation in determining water use of streamflow reduction activities

Estimated cost: R2 500 000
Expected term: 2015-2018

Upstream-downstream hydrological linkages in the Limpopo River Basin

CSIR; Rhodes University (IWR)

No. 2439

The main objective of this research is to establish and quantify upstream–downstream hydrological linkages in the Limpopo River Basin in order to promote transparent and well-informed cooperation between various stakeholders and provide information that will be used to increase resilience to climate change and extreme weather events. The work will provide improved estimates of the water resources of the whole of the Limpopo basin, building on the work previously undertaken. The intention is therefore to also increase the confidence that can be expressed in these estimates for purposes of water sharing, current and future socio-economic development and maintaining ecological integrity of the basin for sustainable development. This is necessary if the water and food security in the basin, and mitigation of flood and drought disasters, are to be achieved. The aims of the project are:

- To identify and delineate the water sources (water towers and recharge areas) in the LRB
- To develop a conceptual model of the flow paths of water in the LRB
- To setup a hydrological model to provide estimates of the water resources of the LRB, that can be used as a basis for planning and management of the basin both for the present and future
- To estimate the impacts of climate change on the hydrology and water resources of the basin

Estimated cost: R1 700 000
Expected term: 2015-2018

Integrated use of isotope tracers to understand the role of surface water-groundwater interaction in salinisation of groundwater resources in arid and semi-arid environments in Southern Africa

Stellenbosch University; Australian National University; University of Kansas; University of Cape Town; GWI Consulting cc

No. 2442

Project aims:

- To develop the methodology for B and Mg isotope analysis in waters and establish this as a standard analytical tool in water research
- To determine the Chlorine 36, Iodine 129, Tritium, Carbon 14 (and possibly tritogenic helium) isotope systematics in saline groundwaters in South Africa in comparison to non-saline groundwaters
- To clarify the origin of salts in various catchments within the Western Cape and Northern Cape using the above isotopes and with conventional geochemistry including stable isotopes of O, H and C as well as radiogenic Sr
- To establish the usefulness of novel isotope tracers (as indicated for Aims 1 and 2 but including stable isotopes of chlorine) for understanding the interaction between surface water and groundwater in areas of salinization
- To build capacity in isotope hydrology within South Africa
- To develop management tools to assist in the management and mitigation of saline groundwater

Estimated cost: R1 400 000
Expected term: 2015-2018

Programme 4: Climate change and water resources

Ocean impact on southern African climate variability and water resources

University of Cape Town; University of Dijon; South African Weather Service

No. 2425

Project aims:

- 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 flood and drought
- To better characterize the role of La Niña on floods in Southern Africa
- To understand the role of adjacent ocean in moisture transport, rainfall and extreme weather and climate of South Africa
- To understand the role of equatorial rainfall variability on Southern African rainfall
- To better characterise the role of ENSO on streamflows in South Africa
- To understand the origin of sea surface temperature bias in the CMIP5 coupled model used by IPCC and their adequacy to reproduce inter-annual and decadal climate variability in Southern Africa
- To understand the role of the ocean on decadal variability of the Southern African climate and explore potential decadal forecasting of Southern African climate

Estimated cost: R1 540 000
Expected term: 2015-2018

Use of Land Surface Models for seasonal hydrological forecasting in South Africa

University of Cape Town; CSIR

No. 2436

The general objective of this project is to combine existing models and resources, as well as institutional strengths and capabilities, in order to further seasonal hydrological forecasting systems for South Africa, by expanding and consolidating the landscape of available products, tools and knowledge and their capabilities and limitations, for improved confidence and uptake of the seasonal forecast products. Specific aims are:

- To create a knowledge basis for an operational system comprising a land surface model linked to regular seasonal climate forecast, enabling regular forecasts of runoff, streamflow, shallow groundwater and soil moisture, addressing aspects such as frequency and intensity of events, as well as mean conditions, and thus enabling generation of a range of user-relevant indices
- To quantify value to hydrological applications of using regionally downscaled seasonal forecasts with an LSM hydrology compared to the forecast based on optimal statistical downscaling of GCM data
- To quantify relative importance of uncertainty in initial conditions (soil moisture, rainfall) compared to that in forecast climate fields, on the skill of seasonal hydrological forecast, and thus to assess the value of hydrological model initialization from observed conditions on the quality of the forecast, and determine spatial and temporal differentiation of sources of forecast skill between the initial hydrological conditions and boundary (meteorological) forcing
- To determine which aspects of forecast processes are robust with respect to the choice of hydrological model and the choice of climate model
- To quantify propagation of uncertainty along the possible data-processing paths, considering possible downscaling pathways: GCM → statistical downscaling → hydrological model → forecast – GCM → RCM → integrated hydrological model → forecast – GCM → RCM → statistical downscaling → off-line hydrological model → forecast – GCM → RCM → off-line hydrological model → forecast
- To consolidate, with user community, a range of application-relevant metrics from the forecast product which are at the intersection of forecast skill and usability within the current decision space and current decision-making paradigms in the water sector and present these in an easy-to-use online platform

Estimated cost: R1 271 360
Expected term: 2015-2018

Predictability of hydroclimatic variability over eastern South Africa under climate change

CSIR

No. 2457

Project aims:

- Estimate changes in climate variability over the summer rainfall region of eastern South Africa under enhanced anthropogenic forcing
- Determine how seasonal predictability may change over the summer rainfall region of eastern South Africa under climate change
- Generate detailed projections of changes in streamflow and dam levels over Lesotho and the

mega-dam area of eastern South Africa, including changes in variability, under climate change
- Quantify the seasonal predictability of stream low and dam levels over the Lesotho and mega-dam area of South Africa under present-day climate
- Determine how climate change may alter the seasonal predictability of streamflow and dam levels over Lesotho and the mega-dam area of eastern South Africa
- Describe the consequence of future changes in the hydrological cycle and its variability over Lesotho and the mega-dam area of eastern South Africa for water security in southern Africa

Estimated cost: R1 257 000
Expected term: 2015-2018

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Pilot study and technology transfer of the Integrated Water Quality Management System (IWQMS) in the Breede-Overberg and an assessment of early warning systems for source water protection

Golder Associates Africa (Pty) Ltd; MHP GeoSpace (Pty) Ltd; University of the Western Cape

No. 2427

Project aims:
- To have the DWA regional office/CMA drawing reports from the system and utilizing these for quarterly and annual reporting
- To unlock the reporting bottlenecks in governance to ensure there is a swift flow of information
- To refine the glitches in the IWQMS based on implementation of the system by various water users
- To report on the progress by the water users, DWA regional office, CMA, municipality and province
- To review and assess EWSs to aid in protecting our source water from over-abstraction and contamination
- To develop response scenarios and conceptual tools and frameworks based on different water management levels
- To develop ideas on how to effectively manage ongoing operation and maintenance of the EWS

Estimated cost: R1 500 000
Expected term: 2015-2017

Evidence-oriented investigation to assess the necessity of purging or non-purging groundwater sampling in selected fractured and alluvial aquifer systems of South Africa

University of the Free State (IGS)

No. 2428

Project aims:
- To develop typical well depth profiles for inorganic chemistry related chemical parameters that are characteristic of groundwater flow zones in the selected aquifer systems
- To evaluate the necessity of purging or non-purging groundwater sampling

Estimated cost: R600 000
Expected term: 2015-2017

Revision of the 1996 South African Water Quality Guidelines – development of risk-based approach for recreational water use

CSIR; Department of Water and Sanitation; Umgeni Water; University of KwaZulu-Natal (Westville)

No. 2435

Project aims:

- To develop a technology demonstrator that will demonstrate the features of recreational water quality guidelines
- To engage with various stakeholders to elicit comment and recommendations
- To maximise synergy with parallel projects on the development of water quality guidelines for other water users, for example, the agricultural irrigation water quality guideline project initiated this current financial year
- To develop a fully-functioning decision support system for selected specific recreational water users

Estimated cost: R2 000 000
Expected term: 2015-2018

Development of novel fluorescent sensors for the screening of emerging chemical pollutants in water

University of Pretoria; CSIR; Department of Water and Sanitation

No. 2438

Project aims:

- To prioritise emerging chemical pollutants in water in order to define target analytes for fluorescence screening (based on, e.g., toxicity, projected concentrations, fluorescence characteristics, etc.) and to identify potential water sampling sites in Gauteng and surrounds
- To synthesise and characterize suitable novel quantum dots (QDs) and QD nanocomposites for use in the proposed fluorescence sensor
- To immobilize the QDs and QD nanocomposites in suitable polymers (such as siloxanes) in order to generate fluorescence sensor prototypes
- To test and optimize the fluorescence sensor prototypes using synthetic standard solutions of the target compound(s) in water
- To determine the hormone mimicking activity of the synthetic standard solutions by means of suitable bioassays
- To test the fluorescence sensor prototypes which performed best with respect to synthetic solution testing in the screening of real (environmental) water samples for the target ECPs
- To determine the hormone mimicking activity of selected real (environmental) water samples (primarily those which screened positive by fluorescence screening)
- To screen additional water samples and extracts from other research projects which tested positive for hormone mimicking activity using the fluorescence sensor

Estimated cost: R438 600
Expected term: 2015-2016

Geophysical delineation and monitoring of AMD in COH

CSIR; Tshwane University of Technology

No. 2440

Project aims:

- Establish relationships between geophysical field parameters (resistivity magnitude and phase angle) and the site-specific physicochemical properties associated with AMD contamination such as elevated salinity (electrical conductivity / total dissolved solids) and SO_4 levels in a karst hydrosystem
- Determine the optimum survey approach and parameters for different anticipated field scenarios, depending on factors such as the required depth of investigation, the desired resolution and the geo-electric structure of the epikarst and underlying karst aquifer
- Conduct field measurements designed to derive a base-line geophysical image of the AMD plume footprint in the study area
- Repeat field measurements after 12 months to enable the monitoring of changes in plume characteristics over time
- Definition of a geophysical monitoring methodology/ strategy that can be applied on an ongoing basis, if required

Estimated cost: R720 240
Expected term: 2015-2017

Development and benchmarking of decision support for aquatic toxicity testing: technology transfer and implementation of the toxicity testing guideline/ technology

Rhodes University

No. 2445

Project aims:

- To develop and implement a technology-based decision support system for the use of aquatic toxicity testing guidelines as a screening and detailed water quality monitoring tool and demonstrate its application in a series of catchments (showing clear relevance to the municipal, mining, agricultural and industrial sectors)
- To develop and build capacity in relevant Department of Water and Sanitation directorate on the use of the developed system and aquatic toxicity testing in general
- To collect toxicological data over one hydrological year and to prepare the reports that will enhance the work of the regulator in assessing compliance/non-compliance
- To highlight quality assurance practices associated with aquatic toxicity testing
- To set relevant catchment-based limits through stakeholder engagements and dialogue
- To develop a decision support system ready for use in the Department of Water and Sanitation
- To benchmark with international compliance monitoring programmes

Estimated cost: R2 000 000
Expected term: 2015-2018

The development of portable Immunoassays for the detection of enteric pathogen species for water quality monitoring

University of Johannesburg; Medical Research Council

No. 2446

Project aims:

- Re-design and modify the current proof-of-concept lateral flow immunoassay (LFIA) test strips for *Salmonella*, *Shigella* and *Vibrio* spp. and *E. coli*
- Manufacture of lateral flow immnuoassay test strips and testing with reference bacterial strains
- Validation and environmental testing of the four LFIA kits

Estimated cost: R780 000
Expected term: 2015-2017

Multi-array sensor technology for polycyclic aromatic hydrocarbons screening in wastewater

University of the Western Cape; City of Cape Town

No. 2454

Project aims:

- Study redox behaviour of PAHs in aqueous solutions
- Develop electrocatalysts for individual PAHs
- Develop multi-array analytical protocol for reference system
- Develop multi-array analytical protocol for multiple PAHs
- Analyse composite samples using multi-array sensor technology
- Validate composite sample analysis by HPLC

Estimated cost: R730 000
Expected term: 2015-2017

EONEMP: The integration of earth observation into the National Eutrophication Monitoring Programme

CyanoLakes; SANSA; University of the Western Cape; DH Environmental Consulting cc; University of KwaZulu-Natal (Pietermaritzburg); Centre for High Performance Computing (CHPC); Department of Water and Sanitation; CSIR; University of Cape Town

No. 2458

Project aims:

- To use MERIS satellite data acquired between 2002 and 2012, and an updated version of the MPH algorithm, to produce information products for chlorophyll *a*, cyanobacteria blooms and invasive aquatic macrophytes for more than 100 South African water bodies
- Use time-series analysis methods and the data products from Aim 1 to determine the spatial extent, severity and change in eutrophication levels, cyanobacteria blooms and invasive aquatic macrophytes between 2002 and 2012 for more than 100 South African water bodies
- To integrate re-formatted and summarised data from Aim 1 into the NEMP Water Management System online database, producing time-series plots and making data available online
- To perform an inter-comparison between retrospective NEMP in-situ data and satellite data products to facilitate validation and calibration of the MPH algorithm
- To develop an operational system using Sentinel-3 OLCI satellite data for near-real-time monitoring of chlorophyll *a*, cyanobacteria blooms and invasive aquatic macrophytes in more than 100 water bodies from 2016 onwards

- To develop an algorithm for Sentinel-3 OLCI using in-situ data collected through fieldwork and ongoing NEMP sampling
- To validate products from Sentinel-3 using in-situ data collected through fieldwork and ongoing NEMP sampling
- To integrate satellite-based information from the Sentinel-3 near-real-time monitoring system into the NEMP website and WMS data archive
- To assess the whereabouts, extent, severity and change in eutrophication, cyanobacteria blooms and invasive aquatic macrophytes between 2016 and 2018 using Sentinel-3 OLCI products
- To develop an online subscription-based public warning service and mobile application for water quality information and cyanobacterial bloom warnings

Estimated cost: R3 000 000
Expected term: 2015-2018

Programme 2: Water quality modelling

Cholera monitoring and response guideline

University of Fort Hare; Department of Water and Sanitation (Eastern Cape)

No. 2432

The overall aim of this research is the development of a cholera monitoring programme for inclusion in the water resource monitoring programme. Specific aims are:

- To assess the various types of wastewater treatment processes that are used in the Eastern Cape Province (ECP)
- To evaluate the laboratories used for sample analyses and whether these are accredited or not
- To verify the analytical methods used in the laboratories in line with the Green Drop reporting system
- To monitor the compliance of the wastewater treatment plants (WWTP) in the Eastern Cape Province to operational standards and determine the rate of and reason(s) for failure of the treatment technologies
- To evaluate the implemented measures put in place to ensure that wastewater treatment occurs during failure
- To assess the prevalence of Vibrio pathogens in discharged final effluents of WWTP and rural waters in the ECP and make recommendations on the factor(s) contributing to the prevalence of these pathogens in rural waters
- To ascertain the strains of Vibrio pathotypes that are common in the aquatic milieu of the Eastern Cape Province as well as their epidemiology, with a view to tackling the recurring scourge of cholera (and cholera-like diarrhoea) outbreaks in South Africa
- To evaluate aquatic animals (including shrimp, fish, crab, crayfish) and vegetables as potential reservoirs of Vibrio pathogens

Estimated cost: R1 260 000
Expected term: 2015-2018

Extending functionality and knowledge transfer of the Water Quality Systems Assessment Model

Rhodes University; Amatola Water

No. 2448

Project aims:

- The development and testing of a diffuse source nutrient input model linked to land cover, to be

integrated within WQSAM
- Validation of algal and hyacinth growth processes within WQSAM using remote-sensing estimates of primary production for selected eutrophic reservoirs
- Extension of water quality variables simulated within WQSAM to include acid mine drainage and microbial water quality, and the application of WQSAM to selected catchments for historical conditions
- The simplification, further testing and consolidation into WQSAM of the sediment transport model, and application to selected catchments for historical conditions
- The incorporation of a cholera prediction model within WQSAM, with application to selected catchments for historical conditions
- WQSAM documentation and knowledge dissemination

Estimated cost: R898 737
Expected term: 2015-2018

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Training manual for groundwater resource management and groundwater governance for municipalities in South Africa

University of the Free State (IGS); Central University of Technology

No. 2447

Project aims:
- Training needs assessment for municipalities
- Development of a draft training manual on groundwater resource management and groundwater governance for municipalities in South Africa
- Pilot testing and evaluation of the draft training manual on groundwater resource management and groundwater governance for municipalities in South Africa
- Production of final training manual on groundwater resource management and groundwater governance for municipalities in South Africa

Estimated cost: R500 000
Expected term: 2015-2017

Development of a web-enabled mine water management vulnerability assessment tool to facilitate resource protection

Emanti Management (Pty) Ltd; SHE Legal

No. 2451

The project aims to:
- Develop a web-based mine water management vulnerability assessment tool to determine areas of vulnerability and adherence to water use licence requirements
- Develop an associated and supportive web-based mine water management priority action plan tool to check implementation/progress with required actions
- Evaluate the tools at selected mines via pilot studies
- Support improved efficiency and effectiveness in mine water management
- Encourage stewardship of mine water management by mines through ownership of vulnerability assessment and priority action plan development and in-house implementation of associated required improvement processes

- Conduct workshops to:
  - Train users in the use of the tools
  - Build communities of practice/shared learning within and between mines
  - Share experiences and associated challenges in mine water management
  - Obtain feedback regarding tool refinements/ improvements
  - Forge relationships between mines and the project team to strengthen the ongoing refinement and development of the tools
- Support ongoing knowledge dissemination and promotion of tool use
- Develop a guideline for use of the tools

Estimated cost: R854 160
Expected term: 2015-2017

Programme 2: Land-water linkages

Characterisation and protection of potential deep aquifers in South Africa

University of the Free State (IGS); University of the Western Cape; DELTA-H (Pty) Ltd; Parsons & Associates
No. 2434

Project aims:
- Provide a state-of-the-science overview of deep groundwater hydrogeology in South Africa
- Consolidate all available and new data on deep aquifers
- Assess the potential of deep groundwater resources in South Africa
- Characterise the deep groundwater systems in South Africa from a geohydrological perspective
- Design pre-emptive protection procedures and policies for deep aquifers
- Create a publically accessible access point for all deep groundwater data

Estimated cost: R1 000 000
Expected term: 2015-2017

Regional water sensitive urban design scenario planning for Cape Town using an urban (geo)hydrology model

Delta-H (Pty) Ltd; City of Cape Town; University of the Free State (Institute for Groundwater Studies); Hydrologic Consulting (Pty) Ltd; Highlands Hydrology (Pty) Ltd
No. 2441

Project aims:
- Quantify the water balance under optimal implementation of WSUD
- Determine the impact and feasibility of up-scaled WSUD using a numerical urban (geo)hydrology model
- Determine the optimal design for up-scaled WSUD using a numerical urban (geo)hydrology model
- Test and demonstrate the use of an urban (geo) hydrology model for WSUD scenario testing

Estimated cost: R1 000 000
Expected term: 2015-2016

State-of-the-art cemetery guidelines: impacts of interments on water resources

University of Pretoria; University of KwaZulu-Natal (Pietermaritzburg); CSIR

No. 2449

Project aims:

- Investigate the risks posed by cemeteries due to decomposition of bodies, mobilization of metals from coffins and so forth, including risk to human health, ecosystems and groundwater quality
- Assess the impact of interments and grave backfill on soil hydrology and vadose zone hydrology
- Assess hydrology and vulnerability of water sources from cemetery sites through soil and water analyses at three case study sites
- Evaluate the suitability of siting of existing cemeteries and their potential for contamination of soil and groundwater using GIS for different municipalities
- Establish minimum requirements document for safe interment practice and cemetery siting

Estimated cost: R1 000 000
Expected term: 2015-2018

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KSA 2: WATER-LINKED ECOSYSTEMS

SCOPE

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 focuses on the protection and sustainable utilisation and management of the aquatic environment and biota (instream, riparian and ground¬water). Stakeholders and communities require an environment that is safe to live in and water resources that are safe for consumption. Therefore, the WRC, through this KSA, will continue to generate knowledge and develop tools or technologies that assist society and managers to sustainably use water and associated resources while at the same time advancing the protection of these critical resources. The products of this research portfolio are used to ensure that everybody in South Africa can experience a safe environment to live in and safe food and drinking water. This KSA has been at the forefront of funding fundamental research that has established the causal effect of human activities on water quality and aquatic ecosystem health, and has worked with different stakeholders to disseminate and transfer research outputs to policy makers and water resource managers.

The portfolio addresses five key issues that are important in managing and utilising water resources and ecosystems: our environment that constantly changes (ecosystems and global change), the process, function and structure driving ecological systems (ecosystem processes), management tools and frameworks that we can use to benefit from aquatic ecosystems (ecosystem management), the sustainable utilisation of our natural infrastructure (ecosystem utilisation), and the means to correct degraded water resources or the whole environment so that they can provide ecosystem services needed by the society (rehabilitation and remediation).

The KSA programmes and initiatives support sustainable development principles as stated in the National Strategy for Sustainable Development (NSSD1). The sustainable development principles are enshrined in the South African Constitution and advocate a whole-system approach. According to those principles, natural resources must be used sustainably, socio-economic systems should be included since they are dependent on ecosystems, and basic human needs must be met to ensure that resources necessary for long-term survival are not destroyed for short-term gain.

OBJECTIVES

The strategic objectives of KSA 2 are as follows:

- To enhance knowledge on healthy ecosystems and preserve biodiversity
- To generate knowledge that informs ecosystem management and the implementation of policy and legislation
- To support the social and economic requirements of society from ecosystems
- To generate innovative approaches that can be used in rehabilitation and restoration of ecosystems
- To develop innovations and knowledge that demonstrate the actual value of ecosystems and support to people's livelihoods
- To improve understanding of the connectivity between land, water, atmosphere and people

THRUSTS AND PROGRAMMES

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: River, wetland, groundwater and dam processes	**Scope:** Programmes to investigate the ecosystem functioning, structure 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, is a topic attracting international interest.
Programme 2: Estuarine, coastal and marine processes	**Scope:** Estuarine, coastal and marine systems are fragile, while they are highly productive ecosystems and are highly sought after as places to live and establish various enterprises. Catchment activities and land uses affect terrestrial water resources and ultimately the estuarine environment, while marine water conditions also have an impact on the estuarine environment and ecosystems. Projects in this programme will generate knowledge about the ecological processes, structure, and functions of ecosystems of these systems. The programme will also address the impact of land uses and marine conditions on ecological processes in the estuarine and coastal environment.
Programme 3: Aquatic, riparian and land connectivity	**Scope:** Research will be conducted to develop understanding of the interconnections among various ecosystems and ecological processes and functions of water resources, terrestrial systems (soil, air and vegetation) and to assess their value to both the catchment and people.
Programme 4: Surface and groundwater interactions	**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.

THRUST 2: ECOSYSTEM MANAGEMENT

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:** Research in this programme will be conducted to develop and refine methods for determining and operationalizing 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: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems	**Scope:** Within this programme research will be conducted to develop an understanding of the effect of anthropogenic disturbance on aquatic ecosystems in various water resources. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage water resources sustainably.
Programme 3: Land-use and aquatic ecosystem management	**Scope:** This programme focuses on enhancing understanding of the effect of human interventions (land uses and decision making) on the environmental health of various water resources and/or ecosystems. As such the programme covers all water resource types, hence the inclusive name of National Aquatic Ecosystem Health Monitoring Programme is used, whereas the name River Health Programme focuses only on rivers.
Programme 4: Integrated environmental and drinking water quality	**Scope:** Within this programme research will be conducted to develop integrated methods and procedures which will be employed to protect people and the environment from the effects of poor water quality. The programme will develop methods and competence to support policies for the issuing of water or ecosystem use authorisations. This will promote the use of research knowledge in managing environmental water quality as required in the ecological Reserve, and thus reduce drinking water treatment costs.
Programme 5: Ecosystem risks and disaster management	**Scope:** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation. Existing tools and procedures will be assessed with the intention of refining/developing them. The success of the programme will be achieved by working closely with water resource managers and relevant government departments.

Programme 6: Biodiversity and conservation	**Scope:** The overall objective of this programme is to develop and integrate knowledge needed by the country in efforts aimed at protecting and preserving our unique biodiversity and natural landscapes. The projects will look at drivers (sociological, political and economic) that are critical in developing the understanding and competence necessary to sustainably manage the aquatic environment and its biodiversity. Collaboration and partnership with other institutions will be considered for this programme to achieve its aim.
Programme 7: Ecosystem governance, legal framework and ethics	**Scope:** Implementation of research outputs and regulations require appropriate governance systems and structures. 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. The research under this programme should develop knowledge needed for good governance of water resources. The research will develop knowledge needed to support policy, planning and development that promote protection of ecosystems and water resources.
Programme 8: Transboundary ecosystem management	**Scope:** This programme will support projects that enhance ecosystem processes and functions, conservation and planning across regional and national borders. Transboundary research has gained some interest in recent years, and neighbouring countries or catchments will have to manage shared natural capital in an integrated manner. Collaborations with neighbouring countries and international funding agencies will be considered for research under this programme.

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Scope: This thrust addresses the rehabilitation, restoration and remediation 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 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. Remediation is the only addition to this portfolio. This is proposed to encourage innovative approaches that can be used in rehabilitation and restoration of water resources and their ecosystems. Research in this thrust will be carried out in collaboration with key stakeholders.

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)	**Scope:** The research conducted within this programme aims to provide protocols for the rehabilitation of rivers wetlands, estuaries and dams/impoundments, with the emphasis on the impacts of mining and forestry through testing and refinement of buffer zones, taking particular care of the role of underground/surface water interactions, soil types and flow dynamics. This is critical in authorising mining around these systems, especially pans (wetlands). This programme also enables a strong focus on green innovations and the role of ecological infrastructure role in securing water and ecosystem services to the benefit of society and the green economy.
Programme 2: Socio-economic dynamics	**Scope:** The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment. The role of society in prioritizing the importance of natural capital, as well as the role of business in interacting responsibly with nature, is emphasized.
Programme 3: Environmental risk management	**Scope:** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation.

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Scope: This research portfolio investigates issues relating to ecosystem services. The research addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to ensure that individuals and communities derive benefits (social, economic, and environmental) from ecosystems. Support will be provided in building the capacity to implement and apply the research findings. The projects in this thrust will develop innovations and knowledge that demonstrate the actual value of ecosystems to people's livelihoods, well-being, and business sustainability.

Programme 1: Environmental economics (goods & services) and accounting	**Scope:** The overall objective of this programme is to investigate ways to evaluate economic benefits of ecosystem products (goods and services). Appropriate methods and their implementation to local conditions will be promoted by research in this programme. The economic opportunities that are presented by ecosystems will be evaluated so that they can be appropriately developed. Different evaluation and accounting methods and tools will be developed and adapted to local conditions.
Programme 2: Ecosystem value-chain and markets	**Scope:** Research in this programme will develop knowledge about developing and strengthening markets for ecosystem services. The research will cover the whole value chain of the ecosystem services' market. There is a growing interest in developing markets for ecosystem services to support local economies in rural and peri-urban areas. The development of tools or procedures to promote payment for ecosystem services needs to be further developed and implemented appropriately. Product development for various markets will also be the focus of this programme. For instance, environment-based business opportunities should be explored and developed since different ecosystems have different products and services that they offer.
Programme 3: Gender, culture and heritage for ecosystems	**Scope:** In their design or implementation, natural resource management (NRM) initiatives overlook critical socio-cultural dimensions of the challenge to advance sustainability. This programme will investigate relationships and associations of gender, culture, heritage and aquatic ecosystems. The relationships and tensions related to gender, ethnicity, population, age and socio-economic status are among the threads in the larger tapestry that comprises the socio-cultural dimension in natural resource management and access to ecosystem services. The programme will also investigate ideas and innovations from indigenous/local knowledge systems that relate to natural resource management.
Programme 4: Green economy and sustainable (green) innovations	**Scope:** People in rural and peri-urban areas rely on ecosystems for their livelihoods. The research in this programme will support economic development that does not violate the sustainability of socio-ecological processes. Projects in this programme will encourage the production of green technologies (biotechnology) and innovations supporting service- and commercial-based sectors. Outputs from research should contribute to improving the lives of people while also contributing to improving the conditions of water resources and the environment at large. The involvement of the business sector and other individual companies will be sought to fast-track implementation of the research output. The projects will contribute to the Water–Energy–Food Nexus Lighthouse of the WRC.

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Scope: This thrust will address research to improve our understanding of the connectivity between land, water, atmosphere and people. Any change in the environment may have an impact on every other environmental factor and this impact should be assessed to be able to quantify the risks and to implement IWRM. This thrust will also focus on the movement of people (migration) and the response of aquatic ecosystems to these population dynamics.

Programme 1: Ecosystems and population dynamics	**Scope:** The impact of social dynamics on ecosystems and the environment will be addressed in this programme. As human population increases, moves and changes in different areas, sociological studies in relation to ecosystems (environment) are needed to support planning and development of rural and urban areas. In most cases, informal settlements are established in the riparian zones of water resources, which exerts pressure on those resources as people demand more services from those resources. In most cases, water resources such as wetlands and rivers become the only available service infrastructure for the homeless and for poor immigrants in urban and peri-urban areas. Research in this programme will support the Water Sensitive Design Lighthouse and greening of cities.
Programme 2: Ecosystems and climate change	**Scope:** This programme will deal with all aspects of climate change in relation to ecosystems. The research will develop knowledge about mitigation of and adaptation to climate change by aquatic biodiversity. The impact of climate change on ecosystem processes, functions, and structure will be given attention in this programme. The knowledge generated will be used to inform policy makers, businesses, and water managers. Aspects such as readiness, or lack thereof, by rural and urban communities to adapt to climate change, as well as ecosystem resilience, will be the subject of this programme.
Programme 3: Ecological thresholds	**Scope:** Research aimed at determining ecological thresholds will be supported in this programme. These studies will assist in developing understanding about how much degradation the environment or ecosystems can tolerate before collapsing or losing resilience. The research will also analyse the costs of restoring ecosystems and their functionality after total collapse, as well as the costs of not restoring or delayed restoration versus proactive prevention of degradation.

RESEARCH PORTFOLIO FOR 2015/16

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: River, wetland, groundwater and dam processes

Ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Phongolo River and floodplain

North-West University; BioAssets Consultants; Ezemvelo KZN Wildlife; University of Johannesburg; University of Venda; University of Zululand

No. 2185

The Pongolapoort Dam was constructed in 1974. This raised concerns related to the influence of the resulting changes in water flows into the Phongolo floodplain. The Phongola Floodplain study was initiated following the request by Ezemvelo KZN Wildlife to address the concerns of the local and regional stakeholders. Many of the environmental concerns stem from a lack of information. Five surveys were undertaken from November 2012 to April 2014 to include two low-flow or dry-season and two high-flow or wet-season surveys. A regional scale risk assessment approach was developed and tested to assess the present ecological state of the ecosystem and threats to its sustainability. Results from this study once incorporated into a management plan should enable Ezemvelo KZN Wildlife to sustain the structure and function of the systems to maintain the provision of key ecosystem services

Cost: R2 552 800
Term: 2012-2015

Programme 2: Estuarine, coastal and marine processes

Identification of wetland processes impacting water resources at catchment scale

CSIR (NRE); Tshwane University of Technology; Wetland Consulting Services (Pty) Ltd

No. 2191

Hydrological models are an approximation of nature, thus accurate results depend on long-term hydrological data with minimal missing data. Initial modelling in the Mokolo catchment was done with minimal data and knowledge of the hydrological processes of the wetlands. The findings can be improved by further studies which will investigate and conceptualise the key dominant hydrological processes of the wetlands, prior to modelling, in order to improve the accuracy of the results. The direction taken by this study to assess the incorporation of wetland process is a step in the right direction, especially

in areas of the country where wetlands are an important hydrological process, not only in understanding but also managing the water resources of the catchment. Thus, a key finding of this study was that there is an insufficient representation of the underlying hydrological processes of wetlands in current water resource assessments. For a number of sub-catchments, the right results are therefore generated for the wrong reasons. Linking this project to other studies, stable isotopes provided an accurate tracer for groundwater in freshwater ecosystems. Stable isotopes proved the most useful in the Waterberg case study in order to identify groundwater discharge in the form of baseflow in the streams. However, stable isotopes did not perform as successfully in the Wilderness case study as a result of the high evaporative signature of the lakes, although they were successful in identifying the groundwater within the aquifer. Some of these studies are still underway, and will close some of the gaps identified in this completed project

Cost: R1 100 000
Term: 2012-2015

Understanding estuarine processes in uMfolozi/uMsunduzi/St Lucia estuary from earth observation data of vegetation composition, distribution and health

CSIR (Earth Observation); Ezemvelo KZN Wildlife; University of KwaZulu-Natal (Pietermaritzburg); Nelson Mandela Metropolitan University

No. 2268

This study explored the utility of earth observation data, consisting of remote sensing and other ancillary data, to provide information on the spatial distribution on the uMfolozi/uMsunduzi/St Lucia estuary vegetation types and condition. The general approach consisted of understanding leaf-to-spaceborne remote sensing of wetland tree species, vegetation community or habitat types and vegetation nutrient status. It was found that 22 spectral bands are optimal for the discrimination of uMfolozi/uMsunduzi/St Lucia estuary tree species. These are bands that are related to the biochemical and biophysical properties of the leaves. Leaf N concentration, an important nutrient in plant growth and development, can be accurately predicted using remote-sensing data. Leaf N variability is highest in spring amongst the uMfolozi/uMsunduzi/St Lucia estuary trees when compared to summer, autumn and winter. Spatial and spectral resolution of modern very-high-resolution imagery, e.g., WorldView-2, RapidEye and SPOT, are sufficient to satisfactorily map and monitor uMfolozi/uMsunduzi/St Lucia estuarine vegetation communities or habitat types. Indigenous forest fragmentation in the uMfolozi/uMsunduzi/St Lucia estuary leads to significant losses in leaf N as most of the land-cover types (e.g. pasture and subsistence farmlands) resulting from forest degradation showed lower leaf N when compared to the original indigenous forest. Low salinity in the lakes and high water level in 2013 caused die-back or expansion of particular habitats. The project concludes that the availability of new multispectral sensors such as RapidEye and WorldView-2 moves remote sensing closer to widespread monitoring of estuarine vegetation condition, including species and nutrient status.

Cost: R2 100 000
Term: 2013-2016

Programme 3: Aquatic, riparian and land connectivity

Connectivity through allochthony: Reciprocal links between adjacent aquatic and terrestrial ecosystems in South Africa

Rhodes University; SA Institute for Aquatic Biodiversity

No. 2186

Different forms of nutrients and energy move across the conceptual boundaries of habitats via organisms' activities or physical processes, and these transfers can represent important food subsidies. Such cross-partition ecological subsidies can augment the nutritional condition, biomass and biodiversity of communities, particularly where local production (or autochthony) alone may be inadequate to support local food webs. Furthermore, organic subsidies can influence population dynamics, community interactions and ecosystem processes, and can represent dominant flux inputs in ecosystem budgets. Our intention was to explore organic nutrient fluxes in relation to a primarily lotic (i.e. flowing) aquatic system at the scale of a hydrological catchment. The overarching aim of this study was to identify and quantify invertebrate- and vertebrate-mediated reciprocal transfers of organic nutrients among aquatic (freshwater, estuarine, near-shore marine) and terrestrial habitats (including the buffer zone between aquatic and terrestrial habitats) in a South African hydrological catchment. We assessed the flux of organic nutrients in a freshwater/estuary/terrestrial region represented by a hydrological catchment, primarily using stable isotope ratios, augmented with stomach contents and/or fatty acid analysis in certain cases. Wherever possible, the isotope and lipid tracer techniques have been used concurrently to cross-validate diet composition of consumers in the habitats of interest (river, riparian zone, land, estuary). Three estuarine and six freshwater sites were selected in the Kowie River, Eastern Cape. Sampling at each site was aimed at assessing as many elements of the food web as possible. Wherever possible, collections included algae, submerged and emergent macrophytes, dominant riparian trees, suspended particulate matter, zooplankton, in-falling terrestrial invertebrates, emerging freshwater invertebrates, aquatic invertebrates, migratory fish, amphibians, wading birds and select aerial predators.

Cost: R1 700 000
Term: 2012-2015

Investigating the impact of landscape connectivity on water-linked ecosystems

Rhodes University (Geography); University of the Witwatersrand

No. 2260

Connectivity is being embraced increasingly by hydrologists, geomorphologists and ecologists as a concept that allows integration of landscape structure and function at a number of temporal and spatial scales. Connectivity allows the free flow of energy and materials through the system and, as a result, mutual adjustment between system components. It is counterbalanced by storage sites, which allow material to be retained in the system. This research has provided insight into the geomorphic processes that influence water-related ecosystems through their effect on fluvial structures and the functional relationships between the channel and adjacent valley floor. By disentangling natural processes from human-induced change the research has potential to inform the assessment of the geomorphic reference

condition for similar upland rivers that have been subject to incision in the past, and will provide guidance toward interventions that aim to restore natural ecosystem function. It will thus contribute to the sustainable management of upland catchments that comprise the main water supply areas of the country. By focusing on the dynamics of sediment storage and reworking of stored sediment the research findings will also address the need to incorporate sediment storage into sediment yield models. The most relevant results on changes to hillslope-channel and channel-valley fill connectivity are integrated in this synthesis to form a broad perspective of how landscape connectivity has changed in the high-rainfall mountainous headwaters of the northern Eastern Cape Province, South Africa. A methodological framework based on methods used in this research is presented as a guide to effective rehabilitation.

Cost: R594 000
Term: 2013-2016

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

FEPAs and flows: Developing methods for ecological Reserve compliance monitoring in freshwater ecosystem priority areas (FEPAs): a case study in the Kouebokkeveld, Western Cape

Freshwater Research Centre; Aurecon Group; Endangered Wildlife Trust; Cape Nature; Southern Waters Ecological Research and Consulting

No. 2340

The main product of the study was the developed of an elementary method – the STandardised REserve Analysis and Monitoring tool (STREAM) – for monitoring the Reserve in catchments characterised by run-of-river abstractions, limited flow monitoring infrastructure, decentralised water resource infrastructure (i.e. rural catchments without large dams with release mechanisms and that control water by means of extensive reticulation systems). The proposed method assesses deviations from Reserve requirements at coarse spatial and temporal resolutions and does so retrospectively. It is not intended for monitoring real-time compliance in complex catchments with major water resource infrastructure, or for developing operating rules for dams. It has been developed with the budget and skills limitations in mind of managers in smaller catchments that have high conservation value. As it currently stands, STREAM comprises a series of Excel spreadsheets incorporating a combination of data entry templates, mathematical and logical functions, together with pivot tables and graphic outputs that require basic Excel skills to generate. STREAM is not intended to assess whether the Reserve is being legally complied with in terms of the National Water Act. The issue of compliance needs to be interrogated beyond the simple fact of whether a certain hydrological value has exceeded a threshold or not, i.e., whether non-compliance equates to 'anything below the Reserve'

Cost: R315 900
Term: 2014-2016

Programme 3: Land-use and aquatic ecosystem management

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; Ixhaphozi Enviro Services CC

No. 2222

The 78 steps of the wetland management framework (WMF) have been developed to match the Eskom Project Life Cycle Model (PLCM). The PLCM is the standard approach used by Eskom in managing its projects. The WMF adds a further dimension to the PLCM in that it provides the means whereby protection of the surface water environment, in particular wetlands, may be integrated into the standard PLCM in a logical manner. This was done so that the WMF may be used at any stage of an Eskom project to identify and address the relevant wetland issues while a project is progressing. The WMF is based on a number of sub-frameworks covering the range of topics needed to address the diverse aspects of wetland management. The following aspects are addressed for each of the 78 steps of the WMF:

- The relevance of the step to the category of focus or impact of the step (legal, environmental, social responsibility and the role of Eskom in the wider catchment management)
- One or more core questions to guide the process to address each step
- The various corporate organizational elements which would be involved, for instance, skills development systems, management of data and information systems

The Robustness of the WMF was tested in four selected case studies, with varying complexity and stage of development or even closure, Case study sites for the testing of the WMF were selected on the criteria of the constructional (Kusile), operational (Matla and Kriel) and return-to-service (Grootvlei) phases of the PLCM. For each of these the level at which the steps of the WMF had been addressed was assessed. In each case, it was found that the legal issues were prioritised, but Kusile was the only power station that had addressed wetland management on the property. Following this, the steps of a wetland management plan for Matla Power Station were drawn up to guide it through the steps necessary to conform to the legal, environmental and corporate responsibilities of Eskom on the site.

Cost: R1 000 000
Term: 2013-2014

The design of a National Wetland Monitoring Programme (NWMP) following a phased approach

Sustento Developments cc; University of KwaZulu-Natal (Pietermaritzburg); University of Cape Town; Duncan Hay and Associates; CSIR; Prime Africa Consultants CC

No. 2269

Wetlands are complex and dynamic ecosystems that provide indispensable services to people and the environment. In order to protect and manage the remaining wetlands of the country, assessment, monitoring and reporting on the state of wetlands is crucial. The South African Department of Water Affairs and Forestry conceptualized a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) in the early 1990s. Although a number of monitoring

programmes have been implemented under the NAEMP, such as the River Health Programme, a wetland monitoring programme has yet to be established. With this need in mind the WRC issued a directed call for a project entitled the design of a National Wetland Monitoring Programme (NWMP) following a phased approach. The phases were:

- Phase 1 – conducting a situation analysis regarding the complexities of monitoring wetland health or integrity and developing a framework that can serve as the basis for Phases 2 and 3
- Phase 2 – designing a monitoring programme and developing an implementation plan
- Phase 3 – pilot testing

The programme was designed with a focus on reporting the national status and trends. However, further detailed levels of assessment were deemed necessary; hence the final product has a three-tier approach. The first tier is monitoring and reporting at status and trends level. The other tiers are more detailed, from ecoregion to site-specific.

Cost: R1 000 000
Term: 2013-2016

Programme 6: Biodiversity and conservation

An investigation of the association between genetic diversity and contaminants in the Klip River system

North-West University (Potchefstroom); University of Johannesburg

No. 2204

In this study it was demonstrated that the BN approach could effectively be used as a tool for water resource and conservation managers. It was able to demonstrate that the water resource management goals can be assessed against the backdrop of different scenarios. The trade-offs of cost and benefits can be evaluated in this way, e.g., it was demonstrated that even with mitigation of AMD in the Klip River, there would still not be any change in the macro-invertebrate status. The graphic nature of the interface and outputs coupled to the ability of the BN models to generate and evaluate alternative scenarios makes it a useful tool for resource management. The application of RRM-BN models can contribute to greater application of adaptive management practices in water resource and conservation management of the Klip River and Upper Vaal WMA. The application value within an adaptive management framework is due to the RRM-BN model communicating uncertainty in a quantifiable manner. It is therefore essential that future studies should focus on the aspects that relate to both human health risk as well as economical risks. As an example, what is the health risk associated with the consumption of fish from the Klip River system or consumption of products irrigated from surface and ground water from the system? Further, what financial risks are associated when irrigation from Klip River water resources is stopped?

Cost: R1 650 000
Term: 2013-2015

Programme 7: Ecosystem governance, legal framework and ethics

Conclusion of the RDM Masters course curriculum

University of Johannesburg

No. 2180

A major concern in South Africa at the time of initiation of this project was the lack of appropriately-qualified individuals with sufficient experience to implement the provisions of the National Water Act, 1998 (NWA), in order to ensure the achievement of integrated water resources management (IWRM). Inadequate and fragmented implementation of transfer of knowledge and capacity has the potential to hinder endeavours to manage water resources in ways that address issues of equity, sustainability and efficiency, and contribute to social and economic development and the eradication of poverty. The Masters curriculum developed provides several study options to students in various participating universities. The participating institutions offer a flexible suite of advanced study options:

- Accredited (SAQA) individual modules and short learning programmes (SLPs), which are credit-bearing towards the Masters.
- A part-time tutored Masters in Environmental Management (M. Env Man) with specialisation in Environmental Water Requirements programme at NWU completed over 2 years encompassing coursework modules and a research project.
- A full- and part-time tutored Masters of Science (MSc) in Environmental Sciences with specialisation in Environmental Water Requirements programme at NWU completed over 2 and 3 years, respectively, encompassing coursework modules and a research project (this degree has been submitted for approval by the Department of Higher Education and Training).
- A full- and part-time tutored Masters of Science in Aquatic Health with specialisation in Environmental Water Requirements programme at UJ completed over 2 and 3 years, respectively, encompassing coursework modules and a research project.

Cost: R1 500 000
Term: 2010-2015

The role of environmental ethics in social-ecological systems and water resource management

Rhodes University (IWR)

No. 2342

This project, on the role of environmental ethics in social-ecological systems and water resource management, arises out of the fact that we are increasingly confronted by the complex and interwoven nature of the complex situations, in which we, as humans – indeed, as all life on earth – find ourselves. Our location and role (as humans) as integral components of social-ecological systems, including our particular and far-reaching powers to impact upon those systems, is critical to the functioning and well-being – and potential survival – of those systems. This raises the implication that we (as humans) may reasonably be seen to have responsibilities to the broader environment, which go beyond our own species and individual personal and social welfare. This nature of this responsibility, and the principles upon which it is argued, is the domain of environmental ethics. The project aims to:

- Review the subject of environmental ethics, and its applicability to the context of integrated water

resource management, and of aquatic ecosystem use and protection

- Investigate case studies, both South African and international, showing the impact of environmental ethics on water resource management and aquatic ecosystems; pay particular attention to best practice cases, and identify the ethics-related factors involved in these situations
- Identify opportunities for application and improvement of environmental ethics in South Africa for constructive management of socio-ecological systems and water resources
- Identify ways in which environmental ethics can constructively be applied in South Africa, and what institutional and other foundations need to be laid/ changes need to be made for this to be possible
- Analyse how environmental value and ethical systems operate at different levels of scale – local, regional and national – and the problems and possibilities of integrating such systems across such differences
- Propose future research in relation to environmental values and ethics in socio-ecological research and water management

Cost: R700 000
Term: 2014-2016

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

The development of a comprehensive manual for river rehabilitation in South Africa

Freshwater Consulting Group; Fluvius Environmental Consultants; Anchor Environmental Consulting; Aurecon Group; Western Cape Department of Agriculture

No. 2270

The River Rehabilitation Manual produced is a three-part series that aims to empower land-users, communities and environmental protection practitioners in the practicable rehabilitation of rivers in South Africa. Even if readers are not planning rehabilitation works, this document aims to create an awareness of processes driving river degradation and solutions, so that small interventions can be identified timeously and can be implemented before the problem escalates and requires much larger interventions. The aim of this project was to develop national guidelines for river rehabilitation that would provide locally appropriate river rehabilitation objectives and structures to enable more effective protection and management of watercourses. The project produced a guide which will be used by implementers in the selection of appropriate rehabilitation solutions to a suite of problems and are presented in three volumes, namely:

1. The Guidelines for River Rehabilitation;
2. A Technical Manual for River Rehabilitation and
3. Case Studies of River Rehabilitation interventions (as a CD)

Cost: R1 000 000
Term: 2013-2016

Programme 2: Socio-economic dynamics

Current and future impacts of alien plant infestations on water temperatures and freshwater biodiversity

Freshwater Research Centre; South African National Parks; Rhodes University (Albany Museum); Nelson Mandela Metropolitan University

No. 2264

Within the study area, the thermal regimes of the rivers are all relatively similar, and by extension all likely to exhibit similar thermal changes in response to global climate change. However, the same species across different rivers exhibit different thermal tolerances, such that ecological responses are likely to differ between rivers. The site-specific densities of alien riparian vegetation appear to have less of an impact on river ecology than major natural land cover types – e.g. fynbos versus indigenous forest. Site-specific levels of alien riparian vegetation density are likely to act as a surrogate for overall upstream catchment transformation, and this is reflected in exceedances of biological thresholds based on mean daily water temperatures. Based on the findings of this study, there is promise towards developing cost-benefit models incorporating targets for thermal reference conditions. This is a key step towards prioritizing areas for clearing of alien invasive vegetation. These findings could be applied not only in the study area, but also at a national scale.

Cost: R934 900
Term: 2013-2015

Building resilient landscapes by linking social networks and social capital to ecological infrastructure

CSIR (NRE); Nelson Mandela Metropolitan University; SA National Parks; WWF South Africa

No. 2267

Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to people. Anthropocentric actions are driving substantial changes to ecological infrastructure and these changes are affecting the resilience of social-ecological systems and their ability to absorb, adapt and recover from disturbance. This in turn exposes society to a wide variety of increasing risks. Protecting or restoring ecological infrastructure is a shared responsibility between government, the private sector and society, and should include both formal and informal mechanisms of working towards a shared response at a landscape level. This project has focused on integrated and systemic ways of approaching risk by linking the concepts of social capacity for governance and social and natural capital to ecological infrastructure in order to build resilient landscapes. The southern Cape region has in the past experienced frequent stochastic events, particularly floods and droughts, and is regarded as vulnerable to the impacts of climate change. Furthermore the Western Cape Government has spent billions of Rand over the past decade on damages associated with environmental risks and impacts. As one of the most risk-prone areas of South Africa we focussed this study on the Eden District. The overarching aim of the project was to promote social-ecological transformation towards a more sustainable future in the Eden District.

Cost: R2 200 000
Term: 2013-2015

THRUST 1: ECOSYSTEM PROCESSES

Programme 3: Aquatic, riparian and land connectivity

Linkages between the hydrodynamic and biological drivers of the Mgobezeleni Catchment

Nelson Mandela Metropolitan University

No. 2259

The understanding gained from an integrated system will develop the tools and understanding to be able to predict the impacts of changes on the hydrology and ecology, and hence on the local communities in the area, in the Zululand Coastal Plain. The project brings together lead scientists with over 150 years of collective research experience, knowledge and management application in the different disciplines of hydrology, ecology, water quality and estuarine system dynamics. The knowledge generated is expected to be applicable to other communities, in particular, in Mozambique and Madagascar. The interaction between surface and subsurface water resources is dependent on many factors that influence the hydrodynamic processes and flow paths in various ways. The plethora of pathways that water can travel from its source to the various points of departure within a catchment are too numerous to mention and impossible to measure. Consequently, the most pragmatic approach to understanding and describing these pathways is through the development and application of three-dimensional numerical models. However these models are very simplistic representations of the natural system. In the Zululand Coastal Plain, groundwater is an important component of the aquatic system and consequently the numerical model must provide a suitable representation of the groundwater hydrodynamics that include direct linkages to the surface water resources and the ecological system. The overriding aim of the project is to determine/understand the goods and services rendered to the ecological system by the hydrological system in a developing environment on a coastal aquifer with various surface water resources that are dominated by the groundwater. The specific aims are:

- Create conceptual and numerical models of the surface and groundwater components involving the interactions of the hydrological systems to support the investigation of biotic and abiotic linkages in a coastal system incorporating the groundwater, lakes, rivers, wetlands, estuary and marine environments
- Create conceptual models of the interactions of the biotic and abiotic components of the hydrodynamic system based on field studies of the groundwater, lakes, rivers and wetlands; these will include a classification of the wetlands based on their drivers, and identification of their sensitivities to change – a special focus will be on peat and how it could be affected by a reduction in water availability
- Create conceptual models of the interaction of the biotic and abiotic components of the hydrodynamic system based on field studies of the hydrology of the estuary and the export of water and nutrients to the marine environment. There will be two components:
  - The export of water, inorganic nutrients and organic matter from the catchment into the near-shore zone of the sea

- The dynamics of the estuary which are controlled by water inflows from the catchment, the growth and breaching of the beach berm that controls the estuary mouth and hence water levels in the estuary; and the vertical and horizontal patterns of salinity within the estuary

- Identify and quantify actual and predictable anthropogenic impacts on the natural environmental components of the Mgobezeleni catchments on the hydro-biological components of the coastal environments
- Create platforms for the capturing, storage and dissemination of spatial and other forms of the biotic and abiotic data collected from the field studies at Mgobezeleni and utilised in the creation of the conceptual models

Estimated cost: R2 700 000
Expected term: 2013-2015

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Integrating a daily disaggregation modelling tool into a water resources simulation model

IWR Water Resources (Pty) Ltd

No. 2263

One of the key principles of integrated water resource management (IWRM) is sustainable management of rivers to preserve ecosystems. To address this need, ecosystem scientists are working to establish (or have established) environmental flows within rivers. To determine the future reliability (ability to consistently meet environmental flows in future) of environmental flows, there is need to integrate environmental flows into catchment-wide water resource management models. However, technical issues arise during integration which need to be resolved. Increasingly ecologists are demanding daily hydrological models to improve their understanding of the link between river flow and ecological response. This issue was addressed in WRC Project K5/1979 and tools were developed to generate daily flow time-series which are consistent with monthly hydrological time-series currently used in water resource planning models. The next step is to integrate this daily aggregation tool into existing water resource models. The water resources planning models currently in use in South Africa all operate at a monthly time step. This is a major stumbling block in assessing the increasingly complex scenarios that ecologists require water resources modellers to evaluate. As an example, the recently published guidelines for the evaluation of estuarine flow requirements require estimates of flood frequencies and how these flood frequencies change under changing development scenarios. This is not possible with the existing monthly models. Within the context of river ecology, the frequency and flood magnitude of spills from dams is becoming increasingly important as catchments become increasing impounded. Again, these crucial parameters cannot be assessed with the current monthly models. A secondary consideration within the framework of daily versus monthly modelling is that of sediment transport modelling. Geomorphologists have for many years only been able to provide broad guidelines to ecologists based on monthly hydrology. A recent positive development within the gemorphological realm of determining ecological flow requirements is WRC Project K5/1797 ‘Implementation of Strategic Adaptive

Management for freshwater protection under the South African National Water Policy', commonly referred to as the *Breonadia* Model. The *Breonadia* Model is essentially a rule-based matrix population model coded in Visual Basic. It requires daily hydrological and rainfall data and starting proportions of different substrate types (which are defined by the site being modelled and which change with time depending on flows) as input data. Hence the provision of daily water resources modelling capabilities will be of huge benefit to the *Breonadia* model. A logical extension of the *Breonadia* model would be to incorporate sediment transport procedures into the proposed daily water resources model. This will then replace the rule-based substrate model with a more scientific approach with the added ability of scenario modelling. A specific request has been made by the *Breonadia* development team to carry out this development. Project aims are:

- Integrate the daily disaggregation model into a water resources model in order to provide ecologists with daily water resources modelling capabilities
- Incorporate flow and sediment routing algorithms into this daily model

Estimated cost: R300 000
Expected term: 2013-2014

The use of long-term, large-scale data combined with historic ecological data to support Reserve implementation

Southern Waters Ecological Research & Consulting
No. 2345

Project aims:

- To use a variety of sources of data to establish a timeline of temporal change in river and wetland ecosystem nature and/or condition at a basin scale
- To identify the main drivers of historical change and, if possible, isolate flow-driven changes
- To augment the basin-level data with site-specific information on riverine community composition, set in the context of the basin-level drivers of historical change
- To provide a template of long-term changes in aquatic ecosystems against which future monitoring of potential impacts associated with abstraction can be evaluated
- To assess key assumptions used in the determination of the ecological Reserve and suggest changes, if necessary and/or appropriate
- To investigate the occurrence and nature of ecological thresholds

Estimated cost: R1 700 000
Expected term: 2014-2018

Quantification of transmission losses along the Letaba River for improved delivery of environmental water requirements (ecological Reserve)

SAEON Ndlovu Node
No. 2338

Project aims:

- Determine environmental water requirement real-time implementation model uncertainties due to transmission loss parameterisation
- Select river reaches under various geological/hydrogeological settings where transmission losses need to be determined
- Select river reaches under various land management types where transmission losses need to be determined

- Quantify abiotic mechanisms for transmission losses in these reaches through groundwater–surface water interaction determination
- Quantify biotic mechanisms for transmission losses in these reaches through determination of actual evapotranspiration losses in the riparian zone
- Upscale the quantified processes through extrapolation with remote sensing, geophysical, hydrochemical and modelling techniques
- Develop accurate transmission loss parameters and incorporate in real-time Reserve implementation models
- Provide added-value by transcribing the findings to other rivers in the Lowveld

Estimated cost: R882 000
Expected term: 2014-2017

Programme 2: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

Investigation of peatland characteristics and processes as well as understanding of their contribution to the South African wetland ecological infrastructure

ARC (Institute for Soil, Climate and Water)
No. 2346

Project aims:

- To update and recalibrate the peatland eco-region database and map to show where peatlands occur and where conditions favourable for peatlands exist
- Improve the existing model to identify potential peatland areas and groundtruth certain of these.
- To develop a strategy for peatland protection
- To develop a South African peatland classification system based on international systems and the SA wetland classification
- To quantify the peatland component in SA's sustainable practice (e.g. cultivation in peatlands)
- To document the cultural heritage associated with SA peatlands.
- To identify peatlands suitable for palynological and related natural archives to study development of the SA landscape over time, climate change and historical human adaption to changes over time in this landscape
- To improve our understanding of threatened and protected species, specifically plant species, that could occur in peatlands, and to simultaneously publish an annotated list of plant species that occur in peatlands based on available sources

Estimated cost: R1 000 000
Expected term: 2014-2017

Programme 3: Land-use and aquatic ecosystem management

Geospatial analysis of microbial community structure and antimicrobial resistance analysis in the management of natural streams and selected wetlands

North-West University (Environmental Sciences & Management)
No. 2347

Project aims:

- To determine and establish water quality of selected surface water sites and classify these based on physico-chemical and microbiological conditions

- To optimize microbial DNA extraction and next generation sequencing methods for establishing microbial biodiversity indices
- To determine the accumulation and attenuation of antibiotic resistant bacteria (ARBs) and genes (ARGs) in water environment at the various sample sites using culture-dependent and culture-independent methods
- To track the origin and movement of ARBs and ARGs from the terrestrial watershed to water environment using comparative and statistical analysis
- To map the landscape to link anthropogenic activities (animal and agriculture operations) with the concentration of ARB and ARGs in the watershed

Estimated cost: R990 000
Expected term: 2014-2017

The investigation of selected Ramsar wetlands biodiversity status and tourism value in support of the Ramsar convention information requirements

North-West University (Biological Sciences)
No. 2352

Project aims:

- Review of available aquatic information for South Africa's RAMSAR sites
- Compilation of available aquatic information of RAMSAR sites into a database
- Management of land use surrounding selected South African RAMSAR sites

Estimated cost: R1 774 700
Expected term: 2014-2017

Aligning and integrating biodiversity and environmental water quality into the mining development life-cycle

Association for Water and Rural Development (AWARD)
No. 2355

Project aims:

- To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management
- To investigate and evaluate the decision-making processes followed in issuing mining authorizations
- To determine the relationship between licensing processes and ecological infrastructure from a landscape and connectivity perspective
- Propose an integrative decision making process and institutional arrangement

Estimated cost: R2 000 000
Expected term: 2014-2017

Programme 4: Integrated environmental and drinking water quality

Development of an immobilized receptor based EDC detection kit

Stellenbosch University (Zoology)
No. 2271

The first reports of synthetic compounds that could interfere with the normal physiological functioning of the endocrine system in mammals, amphibians and reptiles emerged several years ago. The physiological effects of these compounds, later collectively named endocrine-disrupting compounds (EDCs), were observed in lakes, rivers and surface waters in North America and

subsequently Europe. A hallmark of EDC contamination is the low concentrations (lower than mg/L levels) at which these substances can occur in various water sources. Despite the rapid development of detection and screening techniques for specific EDCs, the chemical diversity of EDCs that have the same biological effect is severely hampering the indication of these compounds. It is therefore important to continue the search for sensitive and reproducible assays based on the biological effects of compounds rather than their specific chemical structures. Current consensus is that EDCs pose a significant, long-term environmental risk to the wellbeing of both humans and wildlife. At present, there are no rapid on-site detection systems available for the detection of EDCs with potential estrogenic or androgenic activity. The construction of a rapid, on-site monitoring system could give an initial indication whether particular bodies of water, including wastewater effluent and municipal water supplies, contain EDCs and are, thus, in the long term, fit for use. This kit is not to be used in isolation but rather to serve as the first step in identifying water sources that may be contaminated with EDCs. The key objectives of the project are:

- Synthesis and modification of a PVP spacer arm
- Synthesis of a membrane surface chelating agent, PGEAH
- Assembly of SMA-PVP co-polymer affinity membrane
- Immobilization of ligand binding domains of the androgen and oestrogen receptors on SMA-PVP co-polymer affinity membrane
- Testing EDC binding by immobilized ligand binding domains of the androgen and oestrogen receptors
- Developing a colorimetric visualization method for detection of EDCs
- Validation of membrane based detection method against an ELISA-based method

Estimated cost: R1 070 000
Expected term: 2013-2015

The development and application of periphyton as indicators of flow and nutrient alterations for the management of water resources in South Africa

Freshwater Research Centre

No. 2351

Project aims:

- To broaden the relevance of scientific understanding of periphyton communities in both winter and summer rainfall regions of South Africa to a greater geographical extent
- To test the robustness of periphyton indicators for predicting and monitoring change in the ecological integrity of rivers
- Extend current efforts to test the validity of using rapid in situ methods for determining periphyton biomass in South Africa rivers in general
- To develop a draft protocol for the use of these tools in aquatic biomonitoring in general as well as the RHP and the ecological Reserve process
- To develop preliminary thresholds of change in the trophic state of rivers based on periphyton biomass
- To develop and transfer skills in the use of periphyton as an indicator of change in ecological integrity of South African rivers

Estimated cost: R1 223 574
Expected term: 2014-2017

Programme 5: Ecosystem risks and disaster management

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

Stellenbosch University

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

Programme 8: Transboundary ecosystem management

Development and innovative use of community-based water resource monitoring tools to research and mainstream citizen science and improve transboundary catchment management

Groundtruth cc

No. 2350

Project aims:

- In collaboration with partners in South Africa and each of the six neighbouring transboundary countries, identify and develop existing and new rapid tools for citizen and school learner monitoring of river and catchment health indicators
- Package the tools into an integrated river and catchment monitoring toolkit for roll-out within South Africa and neighbouring countries
- Dissemination of the developed toolkit to promote citizen and school-level education and awareness of catchment and river health
- Through application of the toolkit and geo-database, initiate the growth of a transboundary citizen science dataset of river and catchment health covering South Africa, neighbouring countries and beyond
- Through collaboration with specialists in each neighbouring country, foster research around transboundary water resource management at citizen level
- Assess the successes and barriers to the application of the citizen science tools in effecting meaningful change in the challenges of transboundary water resource management

Estimated cost: R1 432 180
Expected term: 2014-2017

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

Evaluating fish and macroinvertebrate recovery rates in the Rondegat River, Western Cape, after river rehabilitation by alien fish removal using rotenone

SA Institute for Aquatic Biodiversity

No. 2261

One of the greatest threats to South Africa's native freshwater fishes is the negative impact of invasive alien fishes. These impacts include predation, arguably the most serious threat, competition and hybridization. Native fishes in the Cape Floristic Region are characterised by high diversity, endemism and geographic isolation. This makes them vulnerable to the impacts of alien fishes which have extirpated many native fishes from lower reaches of rivers resulting in decreased distributional range and genetic isolation. Many native freshwater fish in the Cape Floristic Region are now red-listed as critically endangered, endangered or vulnerable. In addition, there are strong indications that the loss of native fishes has profound impacts on the aquatic food web.

What is significant from a river rehabilitation perspective is that in many river areas the only impact is the presence of invasive alien fish. By eradicating the alien fish, it is often possible to rehabilitate several kilometres of a river, with very significant benefits for the endangered fish species present and for the associated aquatic biota.

To fully evaluate the use of rotenone as an alien fish removal and river rehabilitation tool it is important that both the immediate and long-term impact of rotenone on community composition and recovery is evaluated. Such research is critical as it will determine whether native fish and invertebrate communities recover after the removal of alien fishes or if the system moves towards an alternative state. To fully assess the consequences of alien fish eradication on the faunal communities in the Rondegat River will require recovery monitoring for a period of at least three years; hence this study. The project will be achieved through the following objectives:

- Determine how the Rondegat River ecosystem responds to the removal of alien fishes over a three-year period
- Assess rates of recovery of invertebrate and fish communities after rotenone treatment over a three-year period
- Test the hypothesis that native invertebrate and fish communities rebuild to approximate those in the non-invaded zone of the river
- Develop post-fish eradication monitoring guidelines for fish and invertebrates
- Provide recommendations for future river rehabilitation projects where alien fish are to be eradicated using rotenone

Estimated cost: R445 320
Expected term: 2013-2016

Assessing the impact of selected methods of removal of alien invasive trees and biomass on fynbos riparian ecosystem functioning

Stellenbosch University

No. 2343

Project aims:

- Evaluate the impact of recommended levels of herbicides used to control alien invasive growth and regeneration on soil microbial diversity and on selected beneficial groups of microbes in situ and ex situ and in riparian soils from two different longitudinal zones
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil microbial diversity and on selected beneficial groups of microbes in situ, and measure regeneration of various native plant species grown in soil from slash-and-burn scars ex situ
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil physical and chemical properties in situ
- Determine the biomass and nutrient content of *Eucalyptus* and *Acacia mearnsii* trees of different sizes growing at different stem densities in riparian sites from two different longitudinal zones

Estimated cost: R1 500 000
Expected term: 2014-2017

Evaluation of the socio-ecological outcomes of wetland rehabilitation in South Africa

Groundtruth cc

No. 2344

Project aims:

- Develop (through iterative application and testing) a monitoring and evaluation framework for the socio-ecological outcomes of wetland rehabilitation in South Africa
- Provide a formative and outcomes-based evaluation of wetland rehabilitation within South Africa, with a focus on the Working for Wetlands operations
- Skills development within the Working for Wetlands programme to allow an internal evaluation of a sub-set of rehabilitated wetlands
- Deepening our understanding of wetland socio-ecology in terms of rehabilitative management
- Specific evaluation of rehabilitation methods employed with the objective of identifying those methods most suitable for labour-based approaches and inform further research
- Contextualize the value of the wetland rehabilitation when viewed as an investment in ecological infrastructure

Estimated cost: R2 500 000
Expected term: 2014-2019

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1: Environmental economics (goods & services) and accounting

Upscaling understanding of water movement, land degradation and carbon cycle in support of effective payment for ecosystem services

University of KwaZulu-Natal (Agriculture, Earth & Environmental Sciences)

No. 2266

Natural ecosystems provide key functions essential to the sustainable economic development of societies. Concerns about long-term sustainability and high environmental costs support the need for an increased understanding of the processes and consequences of land degradation. Land degradation is not limited to an impact on water resources and agricultural production (crop and animal); the living system of the soil also provides a range of ecosystem services that are essential to the wellbeing of farmers and society as a whole. Initially focused on the water resource, Payment for Ecosystem Services (PES) systems now focus on land-water interactions and highlight that catchment condition and, where necessary, rehabilitation, are key to sustained water supply and water quality. However, we still lack an understanding of carbon (C) and nutrient cycles and their role in land rehabilitation techniques. Additionally, there still remain a myriad of unresolved questions and problems related to scale, water quantity and quality, and C and soil nutrient cycles. Addressing these issues remains one of the outstanding challenges in the field of hydrology and environmental sciences and is fundamental in order to foster sustainable economic development in rural areas of South Africa. Moreover, because both the expected results and scale issues are not unique to hydrology there is a range of disciplines, such as meteorology and climatology, geomorphology, soil science/biology and social sciences, which will also benefit from this field of research. As a consequence, we seek through this interdisciplinary project to understand organic C and nutrient cycles from hillslope to basin level, to promote optimal functioning of natural ecosystems. The aims of the project are:

- Upscaling understanding of carbon and nutrient cycles, from the small agricultural catchment to the basin level, through: (i) out-scaling (lateral extension across similar landscapes), and (ii) up-scaling to assess how processes change as the catchment size increases
- Select and evaluate best management practices (BMP) for improved ecosystem functioning and link understanding of carbon and nutrient cycles to remediation activities and Payment for Ecosystem Services (PES)
- Apply BMP at large scale (both spatial and temporal) by running scenarios through improved modelling

Estimated cost: R2 907 000
Expected term: 2013-2018

Evidence-based analysis of environmental degradation: Impact of ecological degradation on water resources, ecosystems and socio-economic development

Prime Africa cc

No. 2272

Degradation of aquatic ecosystems has negative impacts on the economy, and on the health of people and water resources through losses in ecosystems goods and services (EGS). In some cases, the use of the precautionary principle can prevent damage, but this can also prevent economic development. It is thus poor communities who are most often affected by changes in EGS. Rivers, the arteries of a catchment, reflect the health of the environment and the social-ecological system (SES). Any problems in a river basin are reflected in the health of the rivers. The DPSIR model (Driving forces, Pressures, State, Impacts and Responses) provides a framework which enables the drivers exerting the pressure causing the change in the state of the environment to be identified. This directs the response of management to address the drivers, so providing a long-term solution to degradation. There is a lot of research (research outputs include databases and scientific findings) on the degradation of inland waters, but this has not been drawn together into a cohesive whole. The rigorous evidence-based methodology employed by E-BASES (WRC Project K5/1978) will provide a thorough review of the existing knowledge. This, combined with the ecosystem service valuation methods developed by WRC Project K5/1644, will indicate what the cost of environmental degradation has been to the SES. An important part of this work will be to develop a legal view on the standards and level of evidence that would be sufficient to prove liability for ecological degradation. By example, a recent EU directive (EU 2004) has developed a framework of environmental liability based on the polluter-pays principle to prevent and remedy environmental damage, which may provide a way forward in implementing this principle. Specific objectives are:

- To develop appropriate approaches for assessing the causal effect of degraded water resources resulting from catchment land uses on socio-economic development
- To review the subject in the context of water resource and thus aquatic ecosystem goods and services
- To develop or refine approaches and tools needed to analyse the socio-economic impact of environmental destruction or degradation, with special focus on the health and integrity of water resources
- To investigate possible effects of degraded water resources on users and associated food chains and the effect on the benefits derived from the ecosystem goods and services used in both rural and peri-urban/urban catchments
- Apply and provide a critical analysis of the results, including policy implications, opportunities, and threats to local communities and to the country

Estimated cost: R2 000 000
Expected term: 2013-2017

Demonstration of how healthy ecological infrastructure can be utilized to secure water for the benefit of society and the green economy through a programmatic research approach

University of KwaZulu-Natal (Centre for Water Resources)

No. 2354

Project aims:

- To investigate and report on the status of catchment land-use and water resource quality in the selected catchment(s)
- Cost the impacts of the degradation of ecosystem infrastructure on water users from different stakeholder experiences using an evidence-based approach
- Investigate how an intact ecological infrastructure could secure and enhance the benefits provided to society and economy in the catchment
- Investigate how investment in the protection and enhancement of the environmental asset base (or ecological infrastructure) of the uMngeni catchment could contribute to resilient economic growth, greater social equity and justice and the reduction of environmental risks, thereby addressing the goals of the green economy
- With the aid of the stakeholder water resource management framework produced in Phase 1, develop a cost-effective conservation management strategy based on the principles of the green economy
- Develop and train actors in the catchment in an appropriate governance model/approach, which includes social learning, knowledge production (including spatial knowledge), participatory engagement and technical methods (models, guidelines, indicators, procedures) necessary to achieve a paradigm shift to transform society and the economy towards a healthy relationship with the ecological infrastructure within the catchment, i.e., to change the socio-ecological relations in the catchment to ensure greater resilience through the development of a transformative governance approach
- Describe the catchment connectivity in terms of both bio-physical and social aspects that are core in understanding drivers of the catchment processes and characteristics
- Recommend further research on the social and ecological interface critical to improve natural resources governance at the catchment scale

Estimated cost: R5 000 000
Expected term: 2014-2020

Programme 2: Ecosystem value-chain and markets

Investigation of aquatic ecosystem services, their value chain, and markets in South Africa

CSIR (NRE)

No. 2341

The study explores aquatic ecosystem goods and services in South Africa within the context of a value chain assessment:

- To investigate the forward linkages in the value chains of aquatic ecosystem services and their markets in South Africa
- To identify challenges and opportunities in the value chains and existing markets
- To investigate the ripple effects of aquatic ecosystem goods and services in South Africa

- Recommend ways to improve not only aquatic ecosystem goods and services themselves but also the associated value chains

Estimated cost: R1 000 000
Expected term: 2014-2016

Programme 3: Gender, culture and heritage for ecosystems

Explore and incorporate indigenous knowledge systems into natural resource planning policies and government strategies in order to create space for rural community engagement and empowerment aimed at improving their livelihood while sustaining infrastructure

University of the Western Cape (PLAAS)

No. 2353

Project aims:

- To conduct an extensive review on the current uptake of the diversity of indigenous knowledge systems in water resource management policies and strategies
- To establish the implications of the extent to which cultural or indigenous knowledge is considered in the development of strategies meant for decentralization of water resource management, such as catchment management strategies, national biodiversity framework, etc.
- To understand the socio-economic and political perspectives of the value of aquatic ecosystems by rural communities
- Understand how the current distribution of power and gender dynamics impacts decision making in water resource planning strategies and policies
- Develop and test an approach for the inclusion of all knowledge systems (indigenous, scientific and governmental) in policies and strategies for more holistic water management
- Identify future research pathways for the integration of indigenous knowledge systems in policies and strategies

Estimated cost: R1 000 000
Expected term: 2014-2017

Programme 4: Green economy and sustainable (green) innovations

Green water innovations for sustainable aquatic ecosystems and socio-economic development

African Centre for a Green Economy (Africege)

No. 2349

Project aims:

- To evaluate the impact of green innovations on water resources and aquatic ecosystems
- To evaluate the effects of green innovations on corporate performance and society; special focus on South African companies will be prioritised
- To investigate the usefulness and appropriateness of the metrics or indicators that are used to determine the efficiency of green innovations on water resources; recommend a set of indicators that are most appropriate for South Africa
- To recommend specific green innovations that companies should consider to improve the triple bottom-line in South Africa

Estimated cost: R1 333 000
Expected term: 2014-2016

Investigation and demonstration of how integrated green innovations and technologies can be utilized to create entrepreneurship/jobs that improve the economic conditions of communities in the upper Umzimvubu River (Ntabelanga) and Okhombe, within Jo Gqabi and Thukela District Municipalities, respectively

Department of Environmental Affairs; Umhlaba Consulting Group (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); University of Fort Hare (Agronomy); Aquamet; Renen Energy Solutions (Pty) Ltd

No. 2423

Project aims:

- Identify drivers of poverty, opportunities offered by natural ecosystem, and develop community-based vision of a Green Village using a bottom-up approach
- Through integration of indigenous knowledge, green innovations, research, and technology, develop a toolbox of green solutions that can address the impact of climate change and help communities or sectors to adapt to climate change
- Identify and develop a business (economic) framework that poor and local communities can use to improve their livelihoods without furthering land-use degradation
- Develop and test practical and appropriate mechanisms, manuals and guidelines for landscape development and management that will protect the infrastructure and improve ecosystem services
- Train communities (mainly the youth) on appropriate skills/capacity necessary to sustain the businesses and ecosystem services that transform the poor community to be more self-sufficient
- Integrate the green solutions toolbox and business framework with core line-functions of government departments in order to ensure sustainability of the intervention and to forge partnerships with all key stakeholders
- Develop models on how to expand the green toolbox of solutions and business framework utility, from household/village to the national or country-wide scale

Estimated cost: R2 000 000
Expected term: 2015-2018

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 1: Ecosystems and population dynamics

Response of urban and peri-urban aquatic ecosystems to riparian zone land uses and human settlements

Nxt2u (Pty) Ltd

No. 2339

Project aims:

- To complete a literature study on work previously done on challenges regarding informal settlements and consequential degradation of natural resources
- To investigate the regulatory framework that governs human settlements, including processes associated with spatial planning as well as effectiveness of the implementation thereof
- To investigate issues arising from the influx of people into areas that are characterised by sensitive ecosystem and infrastructural resources, including water provision, access and use

- To undertake a pilot study of human-induced impacts on sensitive aquatic ecosystems and changes in ecological dynamics, particularly due to informal settlements
- To investigate the impacts of riparian land-use activities on aquatic ecosystem goods and services
- To develop a framework to propose how ecological resilience can be attained, or how a balance can be struck between human settlements and good ecosystem functioning

Estimated cost: R1 500 000
Expected term: 2014-2017

Programme 2: Ecosystems and climate change

A climate change risk assessment of water hyacinth biological control

University of the Witwatersrand (Animal, Plant & Environmental Sciences)

No. 2265

Alien weed control costs South Africa approximately R6.5 billion per annum, and climate change will impact the effectiveness of those efforts. This project seeks to develop a tool to help manage the outcome of future climate scenarios on alien weed control. Water hyacinth is one of the world's most invasive aquatic plants, originating from South America and invading many ecosystems; its control is crucial. Multiple methods such as mechanical, herbicidal, and biological control have been used against it. However, biological control is considered to be the best long-term, sustainable approach, and is potentially many times more cost effective than other methods, when successful. With such an economic benefit, understanding and improving the success of biological control of water hyacinth is essential. This study proposes to incorporate the effects of biological control by *Neochetina* weevils, with temperature and nutrients, into a model of water hyacinth growth which will give site-specific predictions of population growth of both weevils and water hyacinth, and have applications in climate change risk assessment and management, e.g., by Working for Water. The key project objectives are:

- Model the relationship between environmental temperature and water hyacinth weevil population density and growth
- Model the relationship between water nutrients and water hyacinth population density and growth
- Model the relationship between nutrients and weevil population density and growth
- Combine the above elements to determine how effective biological control of water hyacinth by *Neochetina* weevils will be under different climate scenarios

Estimated cost: R500 000
Expected term: 2013-2016

A multi-proxy investigation into past and present environmental change at Lake St Lucia

University of the Witwatersrand (Chemistry)

No. 2336

Project aims:

- To investigate both the long-term and short-term geomorphic and sedimentological evolution of Lake St Lucia through a combination of geophysical, geochemical, and palaeoenvironmental techniques

- To relate these changes to long-term change in climate, lake water chemistry, and shorter-term anthropogenic influences on the system
- To provide an analysis of climatic controls on the geomorphic and sedimentological evolution of the lake system
- To inform system management practices using insights gained from a longer-term evolutionary perspective

Estimated cost: R849 500
Expected term: 2014-2017

Assessing the effect of global climate change on indigenous and alien fish in the Cape Floristic Region

Freshwater Research Centre

No. 2337

The overall aim of the project is to determine the vulnerability of indigenous fishes to a changing environment:

- To map the current distribution of indigenous and alien fish species in the CFR based on existing and new data
- To evaluate the vulnerability of indigenous fish species and the threat of invasive alien fish species in the CFR under projected climate change
- To characterise flow, habitat and thermal requirements of target fish species
- To determine the thermal ranges and/or thermal preferences of target fish species using field data, niche models, in situ and ex-situ experiments
- To evaluate the likely consequences of climate change on fish species through scenario analysis
- To provide recommendations for the conservation of indigenous fishes in the CFR with a criterion-based evaluation of extinction risk

Estimated cost: R1 860 100
Expected term: 2014-2017

Ecosystem process and function of temporary wetlands: baseline data for climate change predictions

Nelson Mandela Metropolitan University

No. 2348

Project aims:

- Determine the level of biogeochemical cycling generated by primary producers (e.g. micro- and macro-alage) in temporary wetlands during different levels of inundation in order to refine understanding of this process for use in global climate change models
- To examine trophic relationships in temporary wetlands under different levels of inundation and link these to different climate change models
- To experimentally determine different temperature, water level and nutrient regimes that affect the growth and production of various algal taxa, for use and refinement in climate change and eutrophication models
- To determine loss of ecosystem services from temporary wetlands associated with changes in global climate

Estimated cost: R1 500 000
Expected term: 2014-2017

THRUST 1: ECOSYSTEM PROCESSES

Programme 3: Aquatic, riparian and land connectivity

Tools for monitoring and quantifying instream restoration success following removal of alien invasive plants

Stellenbosch University (Conservation Ecology & Entomology); Freshwater Research Centre

No. 2460

A major objective of this project is to develop a composite index or tool to measure stream restoration success following removal of alien and invasive plants. Specific objectives are:

- Determine the effects of riparian restoration on stream species functional diversity and abundance of stream species and compare this to natural and invaded conditions
- Determine the effect that riparian zone restoration has on nutrient cycling (nitrogen) in streams and compare this to natural and invaded conditions
- Quantify the nature and significance of the relationship between functional diversity and abundance of stream organisms and nutrient cycling
- Develop and transfer skills in the assessment of stream surface flow dynamics, nutrient dynamics, aquatic biodiversity, and riparian restoration

Estimated cost: R1 000 000
Expected term: 2015-2018

Developing wetland distribution and transfer functions from Land Type data as a basis for the critical evaluation of wetland delineation guidelines by inclusion of soil water flow dynamics in urban catchment areas

ARC (Institute for Soil, Climate and Water); Terra Soil Science CC; University of the Free State; University of Pretoria; University of Fort Hare

No. 2461

This project aims to provide knowledge to inform policy development and subsequent decision making actions in land use planning involving wetlands. Specific aims are:

- Develop a computer programme to collectively sum and categorize the soils of SA Land Types with redoximorphic through to free drainage soil properties
- Map and quantify the occurrence and regional distribution of soils with redoximorphic features in South Africa based of Land Type Broad Soil Patterns
- Describe and analyse crest to footslope transects reporting on the morphological, physical and chemical soil properties in selected geographic study areas of intensive development in urban Gauteng
- Develop Hillslope (HiTF) and Land Type Transfer (LTTF) Functions by evaluating conceptual hydrological response models for selected developed (urban) Land Types of Gauteng
- Extrapolate and test these conceptual hydrological response models against similar Land Types
- Formulate a statement based on soil, hillslope and Land Type properties towards the regional assessment of wetland guidelines for South Africa

- Populate the Land Type database with pedological data supporting eco-, urban-, mining-, agricultural- and hydrology information and hydrology in general

Estimated cost: R1 000 000
Expected term: 2015-2018

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Environmental water temperature guidelines: bridging the gap between research and implementation
Freshwater Research Centre; University of Venda; University of Cape Town
No. 2537

Project aims:
- To identify requirements of river managers and practitioners for incorporating water temperature into the ecological Reserve
- To develop a protocol for collection and/or derivation of water temperature time-series data
- To develop tools for setting water temperature targets for the ecological Reserve
- To produce a manual for setting water temperature targets for the ecological Reserve
- To disseminate knowledge on the protocol, tools and guidelines through workshops and discussions

Estimated cost: R1 500 000
Expected term: 2016-2019

Programme 2: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

Developing a refined suite of tools for assessing the Present Ecological State of wetland ecosystems
Freshwater Research Centre; Eco-Pulse Environmental Consulting Services; University of KwaZulu-Natal (Pietermaritzburg)
No. 2549

Project aims:
- To engage with key stakeholders to clarify user requirements for a wetland PES assessment tool, and to agree on an assessment framework for different types of wetlands and levels of PES assessment
- To integrate the existing wetland PES assessment tools into a single suite of user-friendly tools, in line with user requirements, and to address the shortcomings of the existing methods
- To undertake iterative testing of draft versions of the PES assessment tool so as to improve the tools that are developed

Estimated cost: R1 500 000
Expected term: 2016-2019

Programme 3: Land-use and aquatic ecosystem management

Refinement of the preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries

Institute of Natural Resources; Nelson Mandela Metropolitan University; Diatom and Environmental Management; Eco-Pulse; University of KwaZulu-Natal (Pietermaritzburg); Institute of Natural Resources

No. 2463

This project will provide human capital development in the water and science sector through three national training and development workshops. It is envisaged that 100 –150 stakeholders, including specialists, authorities and students, will be trained to apply the method developed to determine buffer zones. Specific aims are:

- To undertake national training and development workshops to train stakeholders in how to apply the methodology developed to determine buffer zones
- To develop a refined guideline for the determination of buffer zones for rivers, wetlands and estuaries

Estimated cost: R398 600
Expected term: 2015-2017

Programme 4: Integrated environmental and drinking water quality

The application of ecotoxicity and an activity analysis of salt management to water resource protection and use (domestic, agriculture, mining and industry)

Rhodes University

No. 2462

The project intends to find the best way to manage salinization of freshwater in South Africa. This will be done by testing the toxicity levels of wastewater from different industries or sectors using aquatic biota. A salinization management framework will be developed. Specific aims are:

- To conduct short-term chronic (10–14 days, i.e. 240–336 h) ecotoxicological tests using Caridina nilotica as test organism and toxicologically important major salts (TIMS) specific to municipal wastewater, agriculture, mining and industry
- To use the results from the ecotoxicity tests to develop a set of salinity ranges that correspond to the levels of protection within the resource classification system specific to municipal wastewater, agriculture, mining and industry
- To use the resultant risk-based salinity guideline as the basis for setting resource objectives to contribute to the management of streams potentially impacted by the respective saline effluents from municipal wastewater, agriculture, mining and industry
- To analyse salt management activities in selected agricultural, industrial, mining and domestic (mainly wastewater treatment) facilities and propose a new management practice using Cultural Historical Activity Theory (CHAT)
- To develop a salinization management framework based on the developed SSD salinity risk-based guidelines and CHAT-based management practices

Estimated cost: R2 000 000
Expected term: 2015-2018

A new approach to strategic resource planning for South Africa's estuaries – shifting from an activity-based to a multi-sector paradigm

CSIR (NRE: Marine & Coastal); Nelson Mandela Metropolitan University; Department of Agriculture, Forestry & Fisheries

No. 2464

Project aims:

- The sector-based (or activity-based) approach to estuarine resource planning in South Africa is not sustainable. This research aims to explore an alternative multi-sector approach (tool) using available data and information (already residing within various sectors and the scientific literature) and standardizing formats and outputs suitable for strategic planning processes (e.g. using geo-referenced spatial formats).
- Develop a tool (using spatially-explicit software and/or spreadsheets) to enable intuitive (visual) analysis and interpretation of data and information to inform strategic spatial planning (e.g. through application of spatial analysis technologies).
- Demonstrate to key lead agencies (e.g. DWS, DAFF and DEA) how this tool can be applied to easily identify potential conflicts among sector resource use plans and to explore multi-sector resource use scenarios in order to sensitize managing authorities to the value of joint, multi-sector estuary resource planning.

Estimated cost: R1 796 800
Expected term: 2015-2017

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

Rotenone policy support and capacity development through integrating aquatic-ecosystem monitoring in postgraduate research projects with particular emphasis on HBUs

South African Institute for Aquatic Biodiversity; Rhodes University (Albany Museum); University of Fort Hare; University of Venda ; Stellenbosch University; Cape Nature; University of the Western Cape

No. 2538

Project aims:

- Provide data on ecosystem responses of two rivers and two dams following rotenone treatment to guide national policy on the use of rotenone for alien fish removals
- Test the hypothesis that ecosystem recovery rates in Krom River (invertebrates and fish) will approximate those in the Rondegat River for two years following treatment with rotenone
- Monitor rates of recovery of fish communities in the Rondegat River continuously to determine when complete recovery has occurred by testing the hypothesis that native fish communities rebuild to approximate those in the non-invaded zone of the river within 5 years after treatment
- Assess the recruitment and recovery rates of invertebrate communities to the removal of alien fishes using rotenone in two off-channel dams

- Develop a concept for integrating postgraduate (BSc Honours) projects into a long-term monitoring framework
- Develop human capacity in fish and invertebrate monitoring at Historically Black Universities (HBUs) by integrating postgraduate students and supervisors from HBUs in monitoring projects to develop interest for students to pursue careers in aquatic ecology
- Using lessons learnt from this project in the Western Cape, provide recommendations for the implementation of long-term monitoring projects in river ecosystems in the Eastern Cape and Limpopo Provinces
- Develop a Policy Brief to justify rotenone as the chemical of choice for alien fish eradication; this Policy Brief will facilitate national policy support and buy-in

Estimated cost: R1 443 200
Expected term: 2016-2019

Determining the hydrological functioning of the Palmiet wetlands in the Eastern and Western Cape of South Africa

Institute for Water Research; Parsons & Associates

No. 2548

Project aims:

- Determine the surface and groundwater dynamics of the Kromme River upper catchment (K90A)
- Identify the relationship between wetlands and hydrological functioning of the catchment
- Determine whether wetland degradation is impacting the hydrological integrity of the river, thereby compromising water security and human wellbeing

Estimated cost: R500 000
Expected term: 2016-2018

Programme 2: Socio-economic dynamics

Green village catchment management: guidelines and training

Aurecon; Phuhlisani Solutions cc; University of the Western Cape; AWARD

No. 2508

Project aims:

- To improve water-energy-food security as well as environmental health in rural catchments
- To empower and upskill rural communities to support their own green villages (incl. service delivery)
- To identify stumbling blocks to guideline implementation and catchment management interventions sustainability in rural areas
- To improve the state of rural catchments from the individual–household–village outwards
- To develop an education and skills development programme to support rural job creation to support green villages

Estimated cost: R1 500 000
Expected term: 2015-2019

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1: Environmental economics (goods & services) and accounting

Development of a methodology and decision support system to determine appropriate protection levels of water resources using ecosystem services and socio-economic tools

Prime Africa Consultants cc; Institute of Natural Resources; Golder Associates Africa

No. 2465

There is a need for credible implementation of the Water Resource Classification System. Implementation has been weakened by the existing inconsistencies in the use of the current 7-step guideline. Therefore, this project intends to close this gap. This will support the work of DWS and CMAs. The specific aims are:

- Revise and update the current WRCS Socio-Economic Guideline document
- Investigate and record successes and failures of the current WRCS and Resource Quality Objectives (RQO) socio-economic studies, if any, in addition to those identified as indicated under the rationale for the project
- Address the weaknesses identified in each case
- Undertake gap analysis of current WRCS and RQO socio-economic studies
- Review and recommend standardization of data sources, economic indicators used, analysis approaches and methodologies, and reporting outputs

Estimated cost: R2 000 000
Expected term: 2015-2018

The utilization of water hyacinth (*Eichornia crassipes*) from Hartbeespoort Dam in biogas and bio-fertilizer production, as a solution to water weed challenges

ARC (Institute for Soil, Climate & Water); The Moss Group; University of Pretoria

No. 2543

Project aims:

- To characterise the substrate (water hyacinth and algal soup) and to determine the optimum solid retention time (SRT), hydraulic retention time (HRT) and biogas yield at lab-scale; this information will be used to optimise the design of the digester for the anaerobic digestion of water hyacinth and algal soup obtained from Hartbeespoort Dam
- To co-digest water hyacinth, algal soup and various other substrates in an attempt to maximize bio-methane yield
- To test the effect of catalysts on the digestion process (e.g. certain bacterial species) in an attempt to augment biogas yield
- To determine the microbial composition (using next generation sequencing and DGGE) at various stages of digestion which will aid in selecting the species that may be used in bio-augmentation experiments and to determine the feasibility of the effluent to be used as

a bio-fertilizer (chemical composition and absence of pathogens)
- To conduct a cost–benefit analysis of the system that incorporates anaerobic digestion, in comparison to the current method of dam remediation (i.e. harvesting and composting)
- To determine the social-economic impact of removing water hyacinth and algal soup from Hartbeespoort dam on members of the surrounding communities

Estimated cost: R500 000
Expected term: 2016-2018

Programme 4: Green economy and sustainable (green) innovations

Landscape green innovations to improve aquatic ecosystem services for the benefit of urban and peri-urban communities

African Centre for a Green Economy (Africege); Environmental Monitoring Group; University of Cape Town; NM Envirotech Solutions

No. 2507

Project aims:
- Investigate the nature of landscape innovations suitable for protecting urban and peri-urban aquatic ecosystem services, using Khayelitsha Wetlands Park as a case study
- Investigate the nature of ecosystem services that the wetland provides to local community members
- Identify enterprise development opportunities that can be used to boost community involvement in the protection of the wetland
- Develop a business case for a bankable project locally owned and managed by local community members that addresses issues related to water, food and/or energy security

Estimated cost: R600 000
Expected term: 2015-2017

Pharmaceuticals from South African aquatic plants

University of Pretoria; Mothong Heritage; Walter Sisulu University

No. 2540

Project aims:
- Investigate propagation possibility
- Investigate biological and chemical action of *Mentha longifolia* against melasma
- Investigation of 20 other aquatic plants for treatment of melasma, TB and cancer and for peridontal care

Estimated cost: R2 358 960
Expected term: 2016-2020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 2: Ecosystems and climate change

Long term WRFChem modelling and verification of wet and dry acid deposition over South Africa and investigation of impact of power generation stack emission limits on acid deposition

eScience Associates (Pty) Ltd; University of the Witwatersrand; University of Cape Town; North-West University (Potchefstroom)

No. 2466

The project intends to develop a time-dependent emission inventory using 15 years of climate and deposition data. The project will consider using the WRFchem model to predict dry and wet acid deposition in South Africa. This will be done by modelling future power (stations) emissions with or without SO_2. Results from the model will be verified with actual data (dry and wet acid deposition) from other sources (e.g., Eskom and Josipovic data).

Estimated cost: R700 000
Expected term: 2015-2016

Development of a predictive management tool for Orange River blackfly outbreaks

Groundtruth cc; Red Meat Research & Development SA; Nepid Consultants; Department of Agriculture, Forestry & Fisheries; Philagro SA (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg)

No. 2459

The study will use an integrated approach that includes water variables and farming practices to model and predict blackfly outbreaks. The modelling results will also be used to put together preventative measures, taking into consideration climate change. Specific aims are:

- Test and refine the current probabilistic blackfly outbreak model by inclusion of temperature and turbidity data, and using previous flows and monitoring data
- Undertake climate change scenario analyses to assist future management planning
- Provide an evaluation framework for monitoring data of blackfly larval densities, based on the outbreak model
- Provide a Blackfly Control Programme auditing system using a mobile phone application whereby the general public can report on nuisance levels of adult blackfly
- Capacity building for Blackfly Control Programme (Northern Cape Agriculture) staff

Estimated cost: R1 200 000
Expected term: 2015-2017

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KSA 3: WATER USE AND WASTE MANAGEMENT

SCOPE

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

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, is becoming incrementally scarce. Managing water use and the waste released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it. Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, reuse and treatment of wastewater from domestic to industrial and mining activities has been and is of even greater importance to our country, especially in the light of problems related to the deteriorating quality of our water resources and the rising costs and reliability of

energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond to the issues of poor O&M, competency and capacity constraints, reuse, energy efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

OBJECTIVES

The strategic objectives of KSA 3 are as follows:

- To support the efficient functioning of water service institutions and their viability in order to sustain water services in rural and urban areas
- To develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality
- To develop technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector
- 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 with the aim to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries
- To provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector

THRUSTS AND PROGRAMMES

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. 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.

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Monitoring, management and communication of water quality and public acceptance in the direct reclamation of municipal wastewater for drinking purposes

Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology; CSIR; Stellenbosch University

No. 2212

In South Africa, there has been a lot of interest recently in direct water reclamation (direct potable reuse), for a number of reasons. South Africa, being an arid region, faces serious challenges with availability of conventional water sources. Thus, there is a need to develop standardised terminology for water reuse that is understandable by stakeholders and the public, in order to instil credibility and confidence and for effective (positive) messaging and communication to the general public. The project also compiled recommended water quality monitoring programmes and guidelines for water reuse consisting of constituents and parameters that will require monitoring, including analytical methods, time to obtain results, reliability of method, detection limits, frequency and costs of analyses. The focus should be on on-line (real-time) measurements to ensure that all the required process barriers are intact.

Cost: R547 400
Term: 2013-2015

Assessing the impacts and achievements of the Strategic Framework for Water Services (SFWS)

Sustento Development Services cc; Prime Africa Consultants, CSIR

No. 2415

In 2001 South Africa experienced a shift in the responsibility for provision of water services, devolving from the Department of Water and Sanitation to the local government, as per Constitutional requirements. The regulation and monitoring responsibility remained with central government. With this shift, the Strategic Framework for Water Services (SFWS) was introduced to the water services sector, outlining the changes in approach that were needed to achieve the Constitutional role of local government. The purpose of the Strategic Framework was to put forward a vision for the water services sector in South Africa for 2003-2013, and to set out the framework that would enable the sector vision to be achieved. With the 10-year strategic

timeline of the SFWS being reached in 2013, it was time in 2014 to review and reflect on the strategy. In light of this need, the WRC and Department of Water and Sanitation initiated a study to conduct an assessment of the implicit and explicit impacts of the SFWS and the quantification thereof. The purpose of the study was to understand current gaps; critical problem areas; areas of improvement; and factors of success/failure in implementation of the SFWS. Recommendations were to be provided on how to (i) address these challenges and gaps in the SFWS and (ii) align the water services strategy with new policy/legislation. The study showed that the benefits associated with the SFWS far outweigh the investment costs of the SFWS. The benefit-cost ratio for South Africa in 2013 was estimated at R9.50, i.e., for every R1 invested in water supply and sanitation, a benefit of R9.50 was achieved. This is higher than the ESI average estimate, likely because the methodology used allowed assessment of the compounded benefit-cost impacts of a 10-year SFWS investment programme, i.e., resulting from a continuous reduction in health risks and continuous improvement in livelihoods. By 2013, the cumulative benefits of the SFWS were R130 billion. This included a health cost saving to impacted households of R500 million, a productivity gain in the economy of R800 million and a hugely significant livelihoods impact of R140 000 million. The results showed that the SFWS had achieved its overall aim of improving the health of people, improving livelihoods and protecting the environment.

Cost: R1 672 350
Term: 2014-2016

Risk governance in the South African water sector: business value creation and best practices

Arup (Pty) Ltd; University of Cape Town

No. 2416

The provision of water and sanitation services occurs within a constantly changing and interdependent social, economic, political and environmental context, resulting in a complex set of risks, hazards and uncertainties. Consequently the management of risk is a fundamental requirement for the effective and efficient delivery of water and sanitation services. Historically, risk in water utilities has been managed through traditional linear approaches and usually focusing on operational risks including water quality and asset failure (such as the Blue Drop, Green Drop and No Drop programmes and water safety and wastewater risk abatement planning). However, risks call for a holistic approach that goes beyond the usual linear functions and in the last few years, particularly in international water sectors, a move towards more iterative frameworks of risk governance rather than just risk management is evident. The aim of this study is to understand how water service authorities and water service providers undertake risk governance, and to identify what makes this work and the value this is adding. To achieve this aim, a standard approach to the collection of data was conducted and a risk maturity benchmarking model was developed. The model was used to assess the risk maturity of water sector organisations. The overall average maturity of the organisations varied from 2.4 (initial) to 3.9 (managed) out of a possible score of 5. The water boards and the metropolitan municipalities were observed to have a higher maturity level compared to the small municipalities or municipal entities. It was found that

all organisations assessed undertake risk management primarily in the form of routine risk assessments, water safety and wastewater risk abatement planning. Risk governance is more than just the assessment of risk, however. Most organisations had established some risk governance practices and are moving towards a governance approach to risk at an enterprise level.

Cost: R800 000
Term: 2014-2017

Best practices in sustainable water and wastewater management: a road map to Green Drop and Blue Drop for small- to medium-sized municipalities in SA

Water Group Holdings cc; Sarah Slabbert Associates
No. 2420

The project generated two WIN-SA lessons on best practice in sustainable water and wastewater management: demonstrating a road map to Green Drop and Blue Drop for small- to medium-sized municipalities in South Africa. The two lessons are titled 'Wrapped up! - W_2RAP interventions that paid off for Witzenberg Local Municipality' and 'Risk-based planning delivers safe drinking water to //Khara Hais'. The use of the WRC Wastewater Risk Abatement Planning and Water Safety Planning Guidelines in identifying risks and coming up with interventions within the water and waste water management is showcased. The lessons were workshopped in Upington on 17 November 2015, as a way of encouraging ongoing discussion, debate and lesson sharing for the benefit of other municipalities.

Cost: R500 000
Term: 2014-2015

Programme 5: Water services education and awareness

Islamic jurisprudence and conditions for acceptability of reclamation of wastewater for portable use by Muslim users – case study of eThekwini Municipality

University of Cape Town
No. 2360

Water resonates deeply in the day-to-day lives of Muslims in South Africa and beyond. The research was a very successful first step in documenting the extent of water reclamation projects and developments in Muslim countries. It was even more successful at presenting a detailed framework for understanding the ethical and juridical significance of water in the Islamic tradition. This framework made it possible to address the key questions of the project. Water reclamation was supported by Muslims in a constructive manner. More substantially, the majority of Muslim scholars supported Indirect Portable Reuse. They were concerned about the continuing threats to water, and called for caution in the implementation of water reclamation practices. Muslims, in particular, were still concerned about the threat of medical hazards in the water supply. They asked Muslims and other local communities to be more directly involved in water management practices. At the same time, the religious leaders called upon mosques to lead by example and introduce water saving and recycling measures. They called upon themselves and other religious leaders to raise awareness of water conservation and water management challenges in the country.

Cost: R360 000
Term: 2014-2015

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

Royal HaskoningDHV (Pty) Ltd; Stellenbosch University; Umgeni Water; City of Cape Town; G O Water Management; Chris Swartz Water Utilisation Engineers

No. 2121

Around 2009/10, the Southern and Eastern Cape regions of South Africa experienced the worst drought in known history, and to prevent the risk of complete water supply failure a number of desalination and water reuse projects were undertaken. A substantial amount of literature exists in the public domain with respect to cost and water quality aspects for desalination and reuse plants. However, none of these provide real information on cost and water quality obtained from actual plants constructed in South Africa. This project gathered cost, operational and other data associated with local (South African) desalination and water reuse plants that have been implemented recently and are planned for implementation in the near future. The information gathered during the project will be of beneficial use to municipal engineers and the water community as a whole to define real costs for desalination and reuse. This may be used for more effective future planning and comparison of different water supply options.

Cost: R1 000 000
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; Stellenbosch University; University of Cape Town

No. 2132

Electrohydraulic discharges have been studied for several years; however the integration of innovations in nanoscience and nanophotocatalysis has been incorporated into this area of work on a very limited scale. The present project will focus on the development of the prototype electrohydraulic discharge reactor in order to generate plasma directly in water which will produce radicals from water ionisation. The design of the electrohydraulic system originates from the corona discharge principle. The corona discharge principle is based on a high voltage alternating current between two electrodes which are separated by a layer of dielectric material and a narrow gap through which the oxygen bearing gas is passed. The dielectric is necessary to stabilize the discharge over the entire electrode area so that it does not localize as an intense arc. The prototype system under development consists of two coaxial quartz tubes of 200 mm length with different diameters. The multi-unit inner tubes with 8 OD - 6 ID, which acts as the discharging electrode, is filled with distilled water, and is connected to alternating current (AC) high voltage. The outer tubes comprise tubes with 12 OD- 9 ID leaving 1 mm gap between both tubes where the discharge takes place by the means of throughflowing air. The reactor is submerged in contaminated water which acts as grounded electrode. Furthermore, multiple electrodes across the water flow path in combination with

TiO_2 electrospun nanofibre consolidated photocatalyst that can promote and enhance the oxidants formation will be incorporated in this reactor. Optimisation of the reactor configuration using copper wire electrodes, and then replacement of the initial conventional electrodes with nanowire and synergetic effects of photocatalysis for advanced oxidation processes (AOP) on water treatment is the overall innovation of the project.

Cost: R1 392 800
Term: 2012-2015

A longevity study into the purification capacity of home water treatment devices (HWTDs) supplied in South Africa

University of Johannesburg; National Institute of Occupational Health; University of Pretoria (Virology); CSIR; North-West University (Potchefstroom)
No. 2366

The effectiveness of HWTDs as a mechanism to reduce contaminants from water depends primarily on the water treatment technology that has been utilized by the manufacturers in relation to the quality/source of water that requires treatment. Water treatment devices utilizing AC, IER, ultrafiltration membranes, microporous sedimentation and ceramic filter technologies primarily reduce particulate contaminates by size exclusion due to surface or depth filtration mechanisms; however, efficacy is dependent on pore size. The less porous a water treatment technology is, the more likely it is to result in the deposition of organic on their filtrate surfaces, which leads to biofouling. Additionally, water treatment technologies can become overloaded and saturated with dissolved ions and organic matter if they exceed their lifespan of usage, rendering them ineffective and so vulnerable to biofilm formation. Furthermore, biofilm attachment and growth in HWTDs is highly dependent on the type of materials the device is constructed from (i.e. plastic, rubber) as these materials can all provide a nutrient source for microbial establishment. Moreover, the storage conditions (i.e. temperature), cleanliness, service life/lifespan of usage, water volume throughput and contact time, the use of disinfectant technologies (i.e. KDF or colloidal silver coatings) and the device's ability to absorb chlorine from final treated water are all contributing factors which determine a HWTDs risk for microbial establishment and overall biofouling. The four HWTD filters and filtrate waters that tested positive for isolated pathogenic bio-filming microorganisms were subjected to quantitative microbial risk assessment (QMRA), and two of them did not comply with set WHO criterion annual 'acceptable' risk of infection of 1 in 10 000. These findings suggest that the utilization of these devices to filter Gauteng municipal tap water is not safe and of a great risk to human health, since they are prone to possibly harbour microbial pathogens, which can leach into filtrate water that is intended for human consumption.

Cost: R632 320
Term: 2014-2016

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; University of Johannesburg

No. 2138

Free-living amoebae (FLA) are ubiquitous in natural and man-made water systems. Certain FLA, including. *Acanthamoeba* and *Balamuthia* species are known human pathogens and are carriers of amoeba-resistant bacteria (ARB) known to cause serious, potentially fatal infectious diseases. Members of the genera *Legionella, Mycobacterium, Vibrio, Staphylococcus, Pseudomonas* and others are known ARB often implicated in nosocomial infections. Certain non-pathogenic FLA, for example, *Vermamoeba vermiformis*, are also known carriers of pathogenic ARB. The importance of drinking water quality supplied to and distributed through public health care facilities, with special reference to FLA and certain ARB, has not been studied previously. The study attempted to provide a general overview on the presence of these organisms within water distribution systems of three public health care institutions in Johannesburg, South Africa, and also briefly highlight the potential human health risk implications.

Cost: R423 500
Term: 2012-2015

Water safety and security: emergency response plans

Emanti Management; CSIR; Clive Cumming and Associates

No. 2213

This project aimed to provide guidance on the development of Emergency Response Plans with associated templates in order to protect public health, safety and security. Emergency response planning includes exploring vulnerabilities/threats/challenges, and possible risks (called emergency triggers in this project). The aims of the project were as follows:

- Survey what exists currently in terms of Emergency Response Plans and identify international practices.
- Assist Community Water Services to identify water services and water services infrastructure threats, vulnerabilities and risks.
- Assist Community Water Services to identify management supporting plans and/or documents required in support of risk and asset management focusing on water services emergencies.
- Develop a draft water safety and security Emergency Response Plan (ERP) guideline with useful templates with reference to international ERP practices.
- Workshop the draft guide at selected communities/ municipalities.
- Workshop the guide at local, provincial and national meetings and/or conferences.
- Develop a final ERP guide with inputs and amendments from the pilot and workshops with useful templates.

Cost: R1 500 000
Term: 2013-2015

An assessment of incentivising community engagement in drinking water supply monitoring

University of Cape Town; SeeSaw; Nelson Mandela Metropolitan University

No. 2214

Recent service delivery protests on water and water services provision have highlighted that communication between municipalities and communities is often unsatisfactory, resulting in a lack of trust and constructive engagement. This study was based on the premise that community engagement is paramount to water supply management and sanitation provision. The research proposed an investigation into the use of ICTs in order to engage rural communities in water supply monitoring and the reporting of service faults. The project design was based on using action research in a case study setting with the intention to develop an ICT intervention. Using a number of rurality criteria, two local municipalities in the Eastern Cape were identified as the case study location: Kou-Kamma and Ndlambe municipalities. Both municipalities are water service providers to their communities and exhibit the relevant criteria for being classified rural. In each of the municipalities three communities were identified as case study sites. This project showed that ICT systems can support complaints management in municipalities and can result in a measurable improvement of adaptive capacity. However, the impact and the improvement is arguably not enough to leave either municipalities or the communities in a better position to effectively adapt and respond to the changes. This does not necessarily mean that an ICT is not useful in order to improve the municipal processes, but implementing any system in a rural resource-constrained environment should be done cautiously focusing on the changes that can be achieved when considering the resource limitations.

Cost: R1 170 000
Term: 2013-2016

Detection and quantification of emerging organic pollutants in Durban waterways, and remediation options integrating nanostructured materials and advanced oxidation processes

University of KwaZulu-Natal (Westville)

No. 2215

This work has resulted in protocols that can be used to determine selected PCBs, OCPs, pharmaceuticals and polycyclic musks in environmental samples. The PCB levels were much higher within the Msunduzi River than the Umgeni River, which may be due to various activities along the rivers. Selected pharmaceutical compounds were detected and quantified in both river systems using LC-MS as well as a newly developed GC-MS method. Pharmaceuticals in some wastewater treatment plants in the KwaZulu-Natal region were also determined and levels were mostly found to be higher than in surface waters, as expected, and wastewater could possibly be a source of these contaminants in the river. A method has been developed for the extraction, separation and quantification of polycyclic musks using GC-MS. The method has been successful in quantifying the levels of three selected polycyclic musks in both the Umgeni and Msunduzi Rivers and show significant contamination in both rivers.

Cost: R750 000
Term: 2013-2017

Programme 4: Water distribution and distribution systems

Determination of the change in hydraulic capacity in pipelines

University of Pretoria; TCTA; Rand Water; Department of Water and Sanitation

No. 2140

During this research the hydraulic performance of a number of pipelines were reviewed by conducting field measurements of the energy losses, from which the roughness of the pipelines was calculated. The calculated roughnesses were compared to the documented or referenced roughness for the type of pipe material or liner, from which it was possible to determine the yearly increase of the roughness. The calculated roughness for the different pipelines which were reviewed during this research is well in excess of documented maximum values. In cases where biofilm growth was experienced, the documented long-term expected roughness was significantly less than the calculated roughness. This reflects that whenever biofilm growth occurs, the reference to and use of the surface roughness to determine the hydraulic capacity is unfounded. The higher than published values of the yearly increase in roughness negatively impact the operating capacity of gravity systems and will increase the energy cost of pumping systems. It is therefore imperative that periodic review of the hydraulic performance of conveyance systems should be undertaken.

Cost: R1 125 000
Term: 2012-2015

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Performance and efficacy of integrated algae ponding systems in wastewater treatment for water reuse and cost recovery through biomass valorization

Rhodes University

No. 2123

This report focusses on the IAPS bioprocess, design, component processes and operation, compliance, incorporation of tertiary treatment components, factors affecting the technology, and downstream valorization of the end products. Where necessary, aspects of IAPS technology that impact greenhouse gas (GHG) emissions and climate change have been addressed by life cycle assessment (LCA). Taken together, it is concluded that:

- IAPS is a contemporary wastewater treatment technology that is being intensively studied worldwide and at the water-energy-food nexus for CO_2 sequestration and to derive possible substitutes for fossil fuels.
- Modelling of the kinetic parameters of the Belmont Valley WWTW pilot-scale IAPS advanced facultative pond (AFP)-coupled in-pond digester (IPD) and high rate algae oxidation pond (HRAOP) components confirmed that both organic and hydraulic loading was commensurate with the original design specifications for a 500 person equivalent (PE) system.
- IAPS-treated water complies with the general limit values for either irrigation or discharge into a water

resource that is not a listed water resource for volumes up to 2 ML of treated wastewater on any given day; parameters including chemical oxygen demand (COD), total suspended solids (TSS), pH, dissolved oxygen (DO), electrical conductivity (EC), and N and P values were within the general limit after tertiary treatment by either a maturation pond series (MPS), slow sand filtration (SSF) or controlled rock filtration (CRF); and, there is no faecal sludge handling.

- Large gaps in terms of technology status, design and process operation, and cost of construction exist that can only be addressed following implementation of full-scale commercial systems.
- LCA modelling to map both energy flows and greenhouse gas (GHG) emissions of the Belmont Valley WWTW pilot-scale IAPS treating municipal sewage revealed that an equivalent commercial system would yield –0.16 t CO_2 per ML of wastewater treated, indicating a technology with an ability to mitigate climate change.
- Products from the 500 PE Belmont Valley WWTW pilot-scale IAPS treating municipal wastewater include water for re-cycle and re-use (~28 ML/yr), methane-rich biogas (~1880 kgCH4/yr, equivalent to 26 MW or ~55 kWh/PE per yr), and biomass (>3 t DW/yr).

Cost: R1 500 000
Term: 2012-2015

Development and demonstration of a woven fabric immersed membrane bioreactor package plant for decentralised sanitation

Stellenbosch University; Talbot and Talbot; Veolia Water; Durban University of Technology; Asian Institute of Technology

No. 2287

The overall aim of this project was to develop and demonstrate the woven fabric immersed membrane bioreactor (WFIMBR) as a technology for small-scale and decentralized sanitation. The specific objectives of this project were:

- Developing a 10 person equivalent (PE) package plant sanitation unit based on the novel woven fabric immersed membrane bioreactor technology (WFIMBR)
- Investigating the optimization of the unit in terms of energy usage, simplicity of construction, operation and robustness
- Developing a 30 PE unit based on the optimized geometry and operating conditions
- Demonstrating the 30 PE product to relevant stakeholders, including wastewater treatment practitioners, municipalities, vendors of systems etc., so as to accelerate the implementation of IMBR wastewater treatment package plants in South Africa

A 10 PE WFIMBR was constructed and installed at the Veolia Wastewater Reclamation Plant in Merebank, Durban. Initial investigations were performed on the return-activated-sludge (RAS) stream and activated sludge obtained from the Veolia aerobic digester. Subsequently the project team set up an aerobic digester operating on

the same raw feed as the Veolia plant. This was coupled to a tank containing the membrane modules, and used in further investigations. The product quality and operational stability of the 10 PE unit was investigated. WFIMBR trials for 10 PE steady-state operation (no increase in fouling resistance) was achieved for over a month, while the COD removal was completely consistent with that of most commercial IMBRs. The project was subsequently relocated to the Zandvliet Wastewater Treatment Works in Macassar, Cape Town, where a 30 PE unit was constructed. Although the COD removal was consistent for this trial run, initial investigations indicated that steady-state operation was difficult, as pressure drop across the membrane modules was excessive. Hence the design of the membrane modules was improved. The WFIMBR unit was then evaluated on the RAS stream from the Zeeweed IMBR as well as on the feed stream to the Zeeweed IMBR. The product quality was consistent with that obtained for the 10 PE. conducted at the Veolia Reclamation Plant. However, the process stability differed substantially from the Veolia Plant trials. Furthermore seemingly anomalous observations which contradicted most literature and acceptable operational approaches to IMBRs were observed. The project was subsequently extended to investigate these seemingly anomalous observations instead of demonstrating the 30 PE product. A laboratory-scale WFIMBR rig was established to investigate the authenticity of these anomalous observations and their implication for IMBR technology. In this regard, activated sludges from three local wastewater treatment works (Macassar, Zandvliet and Belville) were investigated in the laboratory trials, and it was confirmed that fouling resistance was lower without air scouring than with air scouring.

Cost: R988 875
Term: 2013-2016

Programme 2: Application of appropriate technologies and tools

WWTP modelling to support the Green Drop programme

University of KwaZulu-Natal (Howard College); eThekwini Municipality; Umgeni Water; University of Cape Town
No. 2221

In this study, both steady state and dynamic wastewater treatment models were evaluated for two case studies, eThekwini's Umhlanga and Phoenix WWTPs and Umgeni Water's Darvill WWTP, respectively, in order to assess the possibility of incorporating modelling as a requirement into the Green Drop Programme. The Umhlanga case study was carried out almost exclusively with data that had already been captured electronically and this was insufficient to resolve a number of questions, especially regarding the sludge age, dissolved oxygen profiles and aeration capacity. It is assumed that many of the data gaps could have been addressed during onsite inspections and interviews with the operators during a process audit; however, this needs to be tested in full-scale field trials. For Phoenix WWTP, the dynamic model

was implemented on the WEST modelling platform. The model development and calibration proved reasonably successful using the established IWA ASM2 model, which, however, was only able to represent the aerobic section of the plant. A comparison with a PWM_SA version also showed satisfactory agreement, which provides a measure of confidence in the new model. However, the anaerobic sludge digesters were not included in the model, as the investigation focused on the influent characterisation. Dynamic modelling with the Darvill WWTP was complex as overloading made the calibration difficult, and as such was unsuccessful. The project outcomes suggest that introducing modelling as a criterion of a Green Drop audit would require municipalities to invest in time and personnel capacity which are currently in short supply. However, the capacity to undertake modelling is something that will be very valuable in the pursuit of the long-term objectives of the Green Drop programme, to improve the standard of risk management in wastewater treatment. The larger municipalities such as eThekwini, Ekurhuleni and City of Cape Town are already investing in this capacity, for their own purposes. However most of the smaller municipalities will not have the necessary resources.

Cost: R700 000
Term: 2013-2016

Energy use reduction at biological nutrient removal activated sludge plants: application of mathematical modelling to find optimum operating and control strategies

TruSense Consulting Services; ERWAT
No. 2377

The aim of this project was to investigate feasible practical aeration energy conservation measures that can be implemented at biological nutrient removal activated sludge plants that not only result in energy use reduction but also ensure final effluent compliance with discharge regulations; thus satisfying both the primary objective of wastewater treatment as well as energy conservation. Two biological nutrient removal activated sludge plants were selected as case studies: (i) Zeekoegat owned and operated by the City of Tshwane with a design capacity of 85 ML/d average dry weather flow and utilising fine bubble diffused aeration and (ii) JP Marais WWTP operated by the East Rand Water Care Company, with a design capacity of 15 ML/d and utilising surface aeration. Zeekoegat is a new plant with the second module and aeration upgrades commissioned in 2013. The plant was designed to minimise aeration energy use with highly efficient fine bubble diffused aeration. Influent flow is also balanced after primary clarification and the plant aeration control system is also optimised to minimise energy wastage. Final effluent complied with all parameter limits except for nitrate/nitrite. JP Marais is an old plant constructed in 1990. The design of the activated sludge process is typical of most activated sludge processes of this era that

were not designed for energy efficiency. The plant uses traditional slow single speed surface aerators which have low energy transfer efficiency. The main objectives of the project were to:

- Identify and evaluate feasible aeration energy conservation measures (ECMs) that not only minimise aeration energy consumption but ensure final effluent compliance with permit requirements
- Determine energy and cost savings as well as capital costs and payback periods for implementing the identified aeration ECMs
- Establish energy use and cost benchmarks for current operation (baseline) and identified aeration ECMs
- Based on international best practices, identify organisation level systems and policies that need to be in place for successful implementation of energy efficiency at wastewater treatment plants

The scope of work for both plants covered, collection and analysis of plant data, determination of 2014 baseline energy use and benchmarking, identification of feasible aeration energy conservation measures, application of advanced process modelling and simulation to determine optimal process and aeration control strategies and economic evaluation of feasible measures.

Cost: R700 000
Term: 2014-2015

Programme 5: Sanitation technology and innovations

Evaluating the design of existing rural school sanitation infrastructure and developing a model and guidelines for optimal design

Partners in Development (Pty) Ltd; Tshwane University of Technology; Walter Sisulu University; Amanz' abantu Services (Pty) Ltd; South African Water and Sanitation Asssociation; WatSup

No. 2381

This report represents an exploration of school sanitation in South Africa, specifically investigating the design of existing rural school sanitation infrastructure and developing a model and guidelines for optimal design. The report explores the background and status of school sanitation in South Africa and its legal environment and looks at best practice for the design of facilities and choice of systems and technologies. The report reveals that the failure or success of infrastructure is fundamentally linked to the needs, resources, attitudes and beliefs of management and the users of school sanitation, and that any attempt to improve the status quo must come from a perspective of a "total solution" which addresses all of these elements coherently. While this report touches on how infrastructure interfaces with user needs and the implications for management, a careful review of models for management, as well as user education, is planned for the future. It is clear that addressing these three elements – infrastructure, management and education – together is vital in order to expect that any intervention might succeed.

Cost: R1 500 000
Term: 2014-2016

Eastern Cape school sanitation – pour-flush pilot

Maluti GSM

No. 2444

Based on the successful demonstration of the pour-flush sanitation technology in a previous project in three Eastern Cape Schools in the Cofimvaba District, and based on the savings which were achieved, this study was initiated to service another two schools: Mbudku and Mvuzo Junior Secondary Schools. The schools were identified with the help of the Department of Basic Education. In the completion of the project training has been provided on O&M.

Cost: R372 100
Term: 2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Strategic assessment and mapping of opportunities for water desalination and water-use optimisation of concentrated solar power generation in South Africa

Escience Associates (Pty) Ltd; University of Stellenbosch

No. 2382

South Africa has a high resource potential for the use of concentrated solar power plants (CSPs), but it has limited water resources. An integrated CSP cost efficiency and water usage model was developed for the three major CSP technologies incorporating air cooling, hybrid cooling and evaporative cooling (evaporative cooling will be used as benchmark and will consider freshwater and saline water options) and was used to identify areas most suitable for CSP development from a cost and water usage point of view. The model gives an accurate indication of the cost per MWh produced on an hourly basis for locations within South Africa with suitable solar resources. Distance from existing and planned transmission infrastructure and distance from transport infrastructure are included, to give an indication of infrastructure-related costs for each location. In considering water availability, freshwater, brackish water, and produced water from other industries is included. In this way the optimal locations can be chosen for future CSPs so that electricity can be produced by CSPs as cost- and water-efficiently as possible.

Cost: R600 000
Term: 2014-2016

Programme 3: Quantification, prediction and minimisation of water use and waste production

Improved analytical strategies for monitoring heavy metals removal in selected wastewater treatment works and constructed wetlands in Gauteng and KwaZulu-Natal Provinces

University of Johannesburg; University of KwaZulu-Natal (Westville)

No. 2116

The focus of this project was the development of analytical techniques and procedures for trace element (metal ion) analysis in wastewater. Baseline evaluation

of current metal concentrations in the effluent samples indicated that some of the WWTPs studied had significant levels of trace metals in the treated effluent. It is important to note that several plants were functioning above their loading capacity, which can impact on parameters such as redox and pH which affect metal ion mobility. Data from the WWTP survey were used to compare the values obtained in our laboratory analyses against those reported by the WWTPs. Generally domestic wastewater treatment plants are designed to process mainly organic matter and nutrients; nitrogen, phosphorus and trace metals are expected to settle out with the sludge. Not much attention is paid to trace metals unless the latter fall within the micro-determinants category. Solid phase extraction techniques based on cationic exchange resins for the speciation of metal ions in wastewater samples were used to establish the fraction of the total metal content that is classified as non-complexed ('free' or labile that is assumed to be toxic) and the fraction classified as complexed (non-labile, assumed to be non-toxic). Sample digestion using different hotplate acid digestion methods for the influent and effluent wastewater was investigated and various filtration methods prior to analyte determination were employed. The HNO_3/H_2O_2 digestion method was the most efficient in the extraction of heavy metals from the raw (influent) wastewater and H_2SO_4/H_2O_2 digestion method showed relatively better efficiency in the extraction of trace metals or digestion of sample matrix for the effluent wastewater. The results obtained showed that, overall Al, As and Pb levels were above the WHO and Department of Water and Sanitation recommended levels. The pre-concentration of Al, As, Cd, Cr, Cu, Ni, Pb and Zn on Dowex 50W-x8 resin from wastewater samples prior to their ICP-OES determination was investigated. The overall results based on the CRMs show that the SPE method using Dowex 50W-x8 resin was suitable and accurate, and validated the results obtained in this study. For organic compounds in wastewater samples, qualitative data were obtained with the GCxGC-TOF MS, and processed using an inbuilt library database. Based on the functionalities, it was predicted that the metals in wastewater samples were predominantly in complexed form. Metal speciation in wastewater samples was carried out using SPE (labile metal fraction) and acid digestion (total dissolved metal) methods. From the data obtained on labile fraction of the total metal content, it was concluded that metal speciation was dominated by the complexes of organic ligands (organic-complexed forms) in both raw and treated wastewater samples.

Cost: R850 000
Term: 2012-2015

Revision of Natsurv 1: Water and Wastewater Management in the Malt Brewing Industry (edition 2)

CSIR; Tshwane University of Technology

No. 2285

Beer production for large breweries amounts to over 6 000 000 barrels (704 087 kL) per annum, medium production is between 15 000 and 6 000 000 barrels and small is less than 15 000 barrels (17 602 kL) per annum. Since the publication of the first edition of Natsurv 1 in 1986, the number of breweries in South Africa has increased from 8 to more than 150. Previously, most breweries were locally-owned; however, current ownership is both national and multi-national for the large breweries, whilst the medium-, small and craft/micro-breweries tend to be

locally owned. Water consumption estimates range from 4 to 8 L/L beer produced, but may be higher in the case of small breweries, generally owing to inefficient water management processes and systems. Water is used for beer production and also for cleaning, sanitation, heating and cooling processes. The malt brewing industry is classified under the food and beverage category and generates three forms of waste: solid (from raw material inputs and packaging), liquid (wastewater from various processes) and gaseous waste. The two predominant streams are solids and liquids. Water used by local breweries is variously obtained from four main sources: borehole, municipal, rain water and fresh water springs. The majority of breweries use municipal water and the quality shows little variation at the different breweries. There are a few breweries that use borehole (well) water and rain water. The pH of wastewater samples (combined waste-water streams) from local malt breweries is circumneutral, which is preferred for the industry internationally. Nitrate loads were much lower at 0.1 mg/L when compared to the 1.5 mg/L described internationally. Parameters such as COD, SS, TDS, TOC, total nitrogen, total phosphorus and soluble ortho-phosphate fall outside of the given ranges or exceed the recommended maximum values; requiring local wastewater pre-treatment before discharge. The study has shown that, for a number of different industrial sectors, there are common technologies available and applicable to reduce resources use and impacts (such as energy and water consumption) and wastewater generation. Many of these technologies would be applicable to breweries in general.

Cost: R700 000
Term: 2013-2016

Water management efficiency: The development and testing of an optimisation model at selected Eskom sites for an integrated water solution

University of the Witwatersrand; Eskom

No. 2289

Volume 1 in this two-volume series focuses on 'Integrated Water and Membrane Network Systems', whilst Volume 2, 'Cooling Tower Model Development' is dedicated to cooling water system design that is characterized by multiple cooling towers. A cooling water system, in the context of this investigation, refers to a cooling tower with its associated set of heat exchangers. In Volume 1, the developed model was validated using Eskom Kriel Power Station. The choice of this 110 ML/day site was informed by the availability of data and willingness of personnel to give guidance on testing and implementation of results. Preliminary results have shown potential savings of more than 12% in freshwater use. This facility operates on a zero liquid effluent discharge philosophy. Consequently, no mention is made of wastewater savings. As part of knowledge transfer, a workshop was conducted at Eskom, demonstrating the applications of process integration in water minimization. Graphical and mathematical optimization techniques were presented in detail. In particular, the attendees were taken through the entire thinking process that is necessary for identification of relevant streams for optimization, as well as characterization of streams into sources and sinks. The developed model has been successfully tested and applied to Eskom Kriel Power Station. Various scenarios were explored and analysed as potential sources for the final design. The most outstanding among the scenarios involved the reuse of blowdown from one cooling tower to

the other and yielded almost 12% savings in freshwater use. This scenario was discussed in detail with the plant personnel and proved to be feasible. In essence, this is currently happening at Lethabo.

Volume 2 is premised on the observation that cooling water systems are generally designed with a set of heat exchangers arranged in parallel. This arrangement results in higher cooling water flow rate and low cooling water return temperature, thus reducing cooling tower efficiency. Previous research on cooling water systems has focused mainly on heat exchanger network thus excluding the interaction between heat exchanger network and the cooling towers. This report presents a technique for grassroot design of cooling water system for wastewater minimization which incorporates the performances of the cooling towers involved. The study focuses mainly on cooling systems consisting of multiple cooling towers that supply a common set of heat exchangers. The heat exchanger network is synthesized using the mathematical optimization technique. This technique is based on superstructure in which all opportunities for cooling water reuse are explored. The cooling tower model is used to predict the thermal performance of the cooling towers.

Cost: R1 500 000
Term: 2013-2016

Revision of Natsurv 2: Water and Wastewater Management in the Metal Finishing Industry (Edition 2)

Stellenbosch University; Metal Finishing Academy of South Africa

No. 2224

A comparison of the Specific Water Index (SWI) results for the metal finishing industry from both the previous study and the current survey are provided. The SWI results indicate that water in the sector is being used more efficiently. In fact, the international benchmark of 40 L/m^2 is improved on by several of the companies surveyed based on an average comparison from 1987 to 2014 of 310 to 95 l/m^2, respectively. Data collected on cleaner production (CP), however, indicates that the uptake of CP is very slow and this could be attributed to financial reasons and the current skill level of operators in the sector. For example, Cr (III) plating plants require more capital investment and the process requires a highly skilled technician to ensure that it operates as intended. The significant financial risk associated with the instability of the economy therefore does not justify the investment in expensive capital equipment nor the hiring of highly skilled labour for operation of a Cr (III) plant. The biggest barrier to the implementation of CP and best practice techniques now, as it was in the 1980s, is financial. Companies are not prepared to invest in CP in an uncertain economic environment, where this investment may not necessarily result in an increased revenue stream.

Cost: R700 000
Term: 2013-2015

Revision of Natsurv 3: Water and Wastewater Management in the Soft Drink Industry (edition 2)

University of KwaZulu-Natal (Howard College); Dube Ngeleza Wiechers Environmental Consultancy Pty (Ltd)

No. 2286

A comparison of the main results from both the previous study and the current survey showed that:

- On average the water used by the soft drink sector has increased approximately 2-fold, however there is a much larger range in water consumption than previously reported.
- Production volumes have increased 4-fold even though the number of soft drink companies in South Africa has reduced overall.
- The average specific water intake (SWI) has decreased from 2.7 litres water per litre product to 1.6 litres water per litre product with a lower range of values.
- As would be expected due to the increase in water use, the average effluent volume has increased (but not in proportion to the increase in water use).
- The average specific effluent volume (SEV) remains constant. No differentiation was made in the 2014 survey between bottling plants with bottle washing facilities and those without.
- The reported COD range is higher in the 2014 survey. This is most likely a result of the lower SWI which can result in a more concentrated pollution load.
- Where reported, the TDS and SS ranges were higher in 2014, but more information is needed to determine if this is a trend. It should be noted that the increase in TDS and SS is due to the inclusion of 100% fruit drink manufacturers.
- The pH range is more variable than previously reported.

It therefore appears that, while the soft drink sector is consuming more water, this water is being used more efficiently than in the past. More data on the pollution concentrations are required before any conclusions can be drawn regarding changes in the pollution load. With regards to best practice, a comparison of specific water intake to benchmark figures shows that the South African companies are operating at a lower specific water intake. An analysis of best practice options implemented by the surveyed companies indicates that the majority are aware of the need to optimise water use thorough internal reuse. There needs to be more focus on preventative management practices such as measuring and monitoring, and raising staff awareness to ensure that water use is optimised and raw materials and product are not wasted.

Cost: R700 000
Term: 2013-2015

Revision of Natsurv 7: Water and Wastewater Management in the Red Meat Industry (Edition 2)

JR Muller & Associates; Enviro Metsi (Pty) Ltd

No. 2385

Internationally, red meat abattoirs (processing cattle, sheep, pigs, ostriches) are known to be high-volume water consumers. Similarly, they are also serious polluters of water due to their effluent. During the 1988 Natsurv 7 survey period, there were 25 registered abattoirs

throughout South Africa. The ten large metropolitan abattoirs (owned by Abakor) processed approximately 50% of the national red meat requirements. In these large abattoirs, weighted process water consumption ranged between 0.7 kL and 1.2 kL per slaughter unit (SU), whilst in smaller abattoirs consumption figures of as high as 4.64 kL per SU was recorded. When the South African meat industry was deregulated in the 1980s, most of the large abattoirs were closed down and smaller abattoirs proliferated. Managers of smaller abattoirs are quite often not seriously concerned with water consumption and effluent quality, as they focus on the quality of meat, which is their core business. Abattoirs in the category of 2 to 20 slaughter units now (2015) represent 45% of the slaughter capacity in South Africa. Water consumed per SU increases inversely to the abattoir slaughter capacity. Average consumption for large abattoirs is 0.91 kL/SU, increasing to 2.04 kL/SU (124%) for small abattoirs. Wastewaters similarly have typical COD values of approx. 1 200 mg/L in large abattoirs and approx. 5 000 mg/L in small abattoirs. Abattoir management can greatly influence the volumes of water consumed as well as the quality of effluent produced in red meat abattoirs. Reducing water consumption and improving effluent quality can have major impacts on the financial viability of red meat abattoirs. To assist abattoirs in reducing water consumption and improving effluent quality, thereby reducing production costs, a best practice guide has been provided. Finally, a detailed action plan has been supplied.

Cost: R700 000
Term: 2014-2016

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Limiting and mitigating the impact of coal mines on wetlands

CSIR; Prime Africa Consultants cc; Coaltech; SANBI; University of Pretoria; Stellenbosch University

No. 2230

By virtue of their positions in the landscape and relationship to drainage networks, wetlands are frequently impacted by coal mining activities, especially opencast methods. The impacts are ongoing, since coal is a strategic resource and will continue to be mined to support the country's development. However, regulatory authorities and the public now have an improved understanding of the range of economic, social, ecological and hydrological costs of wetland loss and degradation. The rules of the game have changed, with regulators increasingly insisting that mines avoid, minimise and mitigate their impacts on wetlands, and internalise the true costs of wetland loss in their balance sheets. Many mining proposals entailing large-scale wetland loss have encountered delays in licence approvals, unrealistic rehabilitation commitments and unwelcome public and media attention. As a result, the coal mining sector has realised that it needs to proactively and systematically address the business risk posed by its impact on wetlands. One of the key project aims was to improve the knowledge and use of appropriate spatial information to guide mining companies and regulators in

their planning and decision-making. This is presented as a High Risk Wetlands Atlas to guide both mining companies and regulators with regard to high risk wetlands and associated landscapes. It identifies key wetland landscapes in the grassland biome of Mpumalanga that are particularly important or irreplaceable in terms of biodiversity, water resource management and ecosystem services. There is a users' guide to the Atlas and a DVD that contains the High Risk Wetlands Atlas, the required software to use it, and the underlying spatial data for those who use their own GIS systems. In addition to the Atlas and its users' guide, other volumes in this set include:

- A review of depressional wetlands (pans) in South Africa, including a water quality classification system
- Wetland offsets: A best practice guideline for South Africa
- Wetland rehabilitation in mining landscapes: An introductory guide
- Assessment of the ecological integrity of the Zaalklapspruit wetland in Mpumalanga (South Africa) before and after rehabilitation: The Grootspruit case study

Cost: R1 056 000
Term: 2013-2016

Mine water atlas of South Africa

Golder Associates Africa (Pty) Ltd (Midrand); University of Pretoria; University of Johannesburg; Council for Geoscience

No. 2234

Mining has been an integral part of the South African economy for over 100 years. The industry employs close to 500 000 workers and contributes 18% to the country's gross domestic product. The mining sector is also a large user of water in certain areas, with the water pollution problems associated with mining being well publicised recently. Relatively small volumes of water are used by mining companies compared to other industrial sectors, but water is needed for extraction and concentration of metals and non-metallic minerals. Water is also used to generate electricity required for crushing ore, on-site processing, smelting, refining and other aspects of treating resources to improve their properties. The crucial difference between mining and other industries is the severe and long-term nature of its impact on aquatic and terrestrial environments – an impact which is widely acknowledged, but has not been mapped in South Africa. For this reason, the WRC embarked on a project to creative South Africa's first South African Mine Water Atlas. The Atlas is a comprehensive reference of the true extent of mine-influenced water in the country, both on the surface and underground. The Atlas informs the implementation of commitments made in the past, while decision-makers will also be able to reference the publication for background information to inform decisions in the future. The first chapters set the scene through an introduction to mine-water and its geological,

hydrological and legal context, and the following chapters provide the geographical foundations of water quantity, quality and distribution across South Africa. The Atlas illustrates South Africa's hydrological characteristics by charting and mapping water resources at the provincial scale: resources, distribution, and the physical setting within which water is found. These features are overlaid with a map of mining activities in order to understand the locations at which surface and groundwater and mining collide. In the next chapters, each of the water management areas is presented by discussing the challenge, the situation, the constraints and opportunities of mine water in each one.

Cost: R2 700 000
Term: 2013-2016

Programme 4: Mining in the 21st century

Mine water treatment technology selection support methodology and tool

Golder Associates Africa; Tshwane University of Technology

No. 2395

Mine impacted water (MIW), and especially acid mine drainage (AMD) treatment facilities are planned and implemented by the mining industry and the public protector. Mine impacted water and the management thereof continues long after production on mines has ceased and it is thus essential that a sustainable solution for impacted mine water management is selected when planning for mining and closure. Several locally developed and imported treatment technologies are available to South African projects. The most appropriate technology has to be project specific. Various factors, including life cycle costs, feed water quality and quantity, product water quality and quantity, waste and by-product generation, environmental aspects, implementation risks, regulatory approval aspects, and interested and affected party buy-in, influence the selection of the most appropriate technology. At present, technology selections are often based on capital costs and existing systems. People feel more confident in implementing processes that have been tested and are running in similar applications. The evaluation tool developed here includes the three pillars of sustainability, namely, the environment, social setting, and economic efficiency, in order to select a balanced sustainable solution to the mine water problem. An additional and crucial factor to be taken into account when selecting a treatment option is ensuring that the option is technically sound. A 'technically sound' theme was added as an up-front screen to the selection tool. This tool is intended to be used by industry to rate and rank alternative embryonic and emerging treatment technologies from the perspective of deployment of emerging technologies. The tool is available as an Excel workbook, and along with the accompanying guide, contains:

- A list of evaluation criteria for mine water treatment technologies through a consultative process
- An evaluation matrix based on the selection criteria identified
- A review or mine water treatment technologies available at the time of writing

- A spreadsheet based tool for use by industry to evaluate treatment options
- A checklist for users and technology providers to ensure that technologies are evaluated on a common platform when using the tool

The guide report also describes the process by which the tool was developed and tested, for readers who wish to interrogate the spreadsheet further.

Cost: R500 000
Term: 2014-2016

THRUST 6: WATERSMART FUND

Programme 1: Watersmart Fund

Water harvesting toolkit for the climate information portal

University of Cape Town
No. 2410

The aim of the project was to provide a free, accessible (easy) interactive, web-based toolkit allowing the use of location-specific up-to-date climate data for design of and learning about small-scale rainwater harvesting systems – rooftop, or small headwater dams. The Climate Information Platform run by Climate Systems Analysis Group hosts a wealth of climate data for the Southern African region. This includes both an archive of historical station data and projected data from climate models. This project utilized the programming environment of the CIP platform to develop functionality allowing users not necessarily familiar with climate data to access datasets hosted by CIP, and conduct location-specific analyses of performance of a rainwater harvesting system. In the general case, the toolkit provides a practical, interactive illustration of rainwater harvesting principles that may facilitate education around rainwater harvesting and conservation of water. In the case of a specific user planning a new or revising existing rainwater harvesting system, the toolkit allows design choices to be explored, taking into consideration climate characteristics of a particular location, leading to a better understanding of the available water resource and a better allocation of budget in the design. The Rainwater Harvesting Toolkit is available at: http://cip.csag.uct.ac.za/waterharvest/. The toolkit allows for interactive assessment of performance of rainwater harvesting systems

Cost: R438 580
Term: 2014-2016

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Development of innovative institutional management scenarios for water services in rural areas

PDG

No. 2209

Rural water supply challenges continue to prevent South Africa from achieving basic service provision to all. While many of the challenges are technical (topography, geography, technology), the dominant obstacle to successful rural water service delivery is finding an institutional model(s) that complements local government as Water Services Authorities and can (i) overcome these technical challenges, (ii) manage scarce resources in an efficient manner, and (iii) provide a continuous and sustainable service. This project seeks to review the available institutional management options for rural water services, as well as introduce possible alternative and innovative management solutions. While many of these models have been debated and assessed before, there has been limited success with these models in South Africa. The study also seeks to go beyond regulatory and technical aspects, and cover a spectrum of socio-political dynamics, economics, and culture, as well as investigate a wider range of potential institutional partners (Water User Associations, mines, etc.). This is particularly relevant given that the DWA Institutional Reform and Re-Alignment process has highlighted the institutional gap around the management of local water resources.

Estimated cost: R1 620 113
Expected term: 2013-2015

Revising the DWA guidelines on municipal tariffs for water services

Nelson Mandela Metropolitan University

No. 2356

In their capacity as the policy leader for Water Services Authorities and Providers (WSAs and WSPs) in South Africa, the South African Department of Water Affairs (DWA, now the Department of Water and Sanitation, Department of Water and Sanitation) have issued guidelines for financial and water services managers involved in setting retail water and sanitation tariffs for standardised piped water service packages; the most recent of which were issued in 2011 (DWA, 2011). The guidelines favour a homogeneity in water service delivery package (a similar quality of piped water service for rich and poor), retail tariff setting to recover the on-going capital and operating costs, a distinction between potable water provision and waste water management (sanitation) services, and retail tariff structures comprised of one or two parts, customised to several different categories of user demand. One part of the tariff structure is related to usage and another to access (and is fixed). The guidelines

recommend that the part of tariffs related to usage should rise in incremental steps as household demand does, that is, an increasing (and therefore also non-linear) block tariff (IBT) structure. Not only is a water service tariff structure the key element in raising revenue to offset the costs incurred in provision, it also is a key element in allocating water services provided, and influences a wide range of choices and decisions, many of which are closely linked to local and regional economic development. South African water tariffs are not set endogenously through the interaction of demand and supply, so automatically taking into account a whole range market influences, but within a constitutionally mandated monopoly market setting. As a result setting water service tariffs has largely become a municipal discretion. It is a discretion that requires some negotiation, but also permits a wide range of options, e.g., choosing a water service provider (or composite of firms that will supply), choosing what water service packages will be offered and choosing the revenue-raising mechanisms that will be employed to recover costs. It is also a discretion that can benefit by more informed guidance. This research will provide a context and framework for this discretion to be exercised.

Estimated cost: R1 600 000
Expected term: 2014-2017

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; City of Cape Town
No. 2120

This study presents evidence, based on ethnographic research focused on the provision of janitorial services in three informal settlements (two in Cape Town and one in Overstrand). The specific aims of the study were to interrogate the introduction and/or provision of janitorial services in public flush toilet facilities in three Western Cape informal settlements, which meant documenting, analysing and understanding imperatives for and obstacles to providing and managing public flush toilets in informal settlements. Key findings from the research indicated that all role-players involved in using and/or providing informal settlement municipally-provided sanitation services:

- Experience health and safety risks which led to their being fearful and which affected their access (i.e. having the right to enter, get near, or make use of something) to toilets/sites
- Experience difficulty reliably coordinating the various interests/processes associated with cleaning/managing sanitation services

- Have diverse and thus different expectations of what constitutes a free basic sanitation service, and of what should comprise the associated responsibilities of users and of various kinds of service providers
- Influence municipal policy through practice
- Experience lack of guidance from national policymakers when providing services for informal settlements

In addition:

- Municipal incapacity and inflexible institutional processes that impede effective service delivery
- Residents' alternative sanitation practices negate the aims of the state's Free Basic Sanitation strategy
- Officials tended to set-up, in preference, centrally-administered and standardized systems, whilst janitors and residents preferred to have initiatives that were tailored especially to their particular situations
- Municipal authorities and contracted workers (e.g. service providers and janitors) are held legally accountable/responsible for delegated tasks, whereas resident users cannot be legally bound to fulfill O&M responsibilities.
- 'Public' janitorial services are generally more effective/reliable than 'community' systems in informal settlements because:
  - Officials and residents had similar expectations of who could access the facilities and who is responsible for the services
  - Despite being under-resourced, municipalities seemed better equipped than residents to manage cleaning services

Cost: R1 000 000
Term: 2012-2014

An investigation into the social, institutional and economic implications of reusing reclaimed wastewater for domestic application in South Africa

Cape Peninsula University of Technology

No. 2208

This study is situated in the context of the social and environmental problems South Africa will be facing over the next five years. With the effects of climate change and depletion of the current water resources, alternative water supply such as reuse is becoming common. Experience at Windhoek demonstrates that a direct wastewater reclamation system can be a practical, responsible way of augmenting potable water supplies in arid regions, but requires comprehensive planning, training and ongoing commitment for its continued success. National and local policies should support reuse of wastewater, taking the constraints of the region as well as the potential threats of wastewater reuse into consideration. Active participation through educational programmes is needed to encourage planners and engineers to design systems that cater for reuse or that can at any time be changed to a reuse scheme. Despite people's acknowledgement of the water scarcity of their countries, it is found that the general public in most communities has little knowledge of its water and wastewater treatment and distribution systems. To gain public acceptance of direct reuse of reclaimed wastewater, experts (including engineers, scientists and physicians) should agree that reclaimed wastewater is safe to use from a public health standpoint. In addition to this, the list of promoting factors such as water shortage, gradual introduction of water reuse, and agreement amongst experts should be brought forward. Current literature, with the exception of work on Australia, seems to be almost silent on community awareness

and/or engagement on the issue of using wastewater for reclamation. This need to engage communities is a principle enshrined within the South African Constitution and is reiterated in the water service regulation strategy, which emphasises the need for a citizens' voice. The lack of understanding or underestimation of this need cannot be more vividly illustrated than by the numerous service delivery protests riddling South Africa, stemming from community experiences and perceptions of unsatisfactory, inefficient service delivery, with drinking water quality being no exception. The results of this project will assist the government and its various services with an understanding of the implications of using treating wastewater effluent for drinking and its consequences from social, economic and institutional perspectives.

Estimated cost: R1 180 000
Expected term: 2013-2016

An investigation into the barriers to implementation of effective wastewater charges by municipalities in South Africa

Prime Africa Consultants (previously CIC International)
No. 2210

There is a lack of understanding, at a municipal level, of the core principles underlying the setting of wastewater treatment charges (some municipalities also refer to these charges in their bylaws as sanitation tariffs). Wastewater treatment charge structures currently used by many municipalities are outdated and are, with a few exceptions, minimally related to the realities on the ground. Green Drop results over the past few years have shown that most municipalities treat water ineffectively, and anecdotal evidence lays some of the blame for this state of affairs at the insufficient budgets available for water treatment. Although many other problems hamper effective wastewater treatment, including an absence of ring-fencing of income from wastewater rates, the most basic point of departure for a sustainable wastewater treatment sector, is to get the price right, i.e., the wastewater charge. The wastewater charge is not only informed by the costs of wastewater treatment. Municipalities are also aware that excessive municipal rates may serve as disincentives to investment. Thus arises an interesting competitive phenomenon between municipalities (especially metros). Much excellent work has been conducted in South Africa on informing water-related tariffs, yet, in spite of this, municipalities still seem to face barriers in implementing these tariffs. This is to the detriment of an effective wastewater treatment sector in South Africa. The aims of this research are to investigate these barriers, to recommend corrective actions, and to raise awareness among municipalities around the development and implementation of effective wastewater treatment tariffs.

Estimated cost: R600 000
Expected term: 2013-2016

Adaptive climate change technologies and approaches for local governments: water sector response

Development Bank of Southern Africa; Department of Environmental Affairs and Tourism; SALGA; Department of Cooperative Governance and Traditional Affairs; University of Cape Town; CSIR; University of Pretoria; Hydrosoft Institute; Department of Water and Sanitation

No. 2283

Project aims:

- To develop a water sector guide of the most relevant adaptation technologies and approaches to climate change over the short-, medium- and long-term for local governments in South Africa
- Identify which local municipalities will need to consider adaptation technologies and approaches to climate change
- Develop a set of criteria to classify adaptive technologies and approaches
- Identify which water distribution and wastewater options are appropriate as adaptive technologies or approaches to climate change at a local government, community and household level
- Map these technologies for near-, medium- and long-term planning and preparation for climate change for the different types of local municipalities (rural, urban and metros)
- Ascertain the institutional and capacity requirements of local government to roll out a climate change adaptation strategy
- Define the practical implementation steps and planning horizons that will be required
- Provide a comprehensive review and way forward for current research (inclusive of all WRC studies) that could provide future solutions for the gaps in the sector, and to meet climate-change projected needs

Estimated cost: R1 500 000
Expected term: 2013-2016

Loss aversion and water conservation

University of Cape Town

No. 2357

As a water-scarce country, South Africa must apply its available water resources in the most efficient and equitable manner possible. In its Water for Growth and Development Plan, identifying water scarcity in major urban centres, the Department of Water and Sanitation has highlighted the importance of water conservation and demand management and, specifically, 'nurturing attitudinal and behavioural changes towards the value of water' Through low-cost and non-pecuniary measures, this project aims to make the 'value of water' salient (explicit) to residential consumers, thereby shifting behaviour towards greater water efficiency. To do so, this study proposes to use insights from behavioural economics to incentivize a reduction in residential water consumption. The study will examine whether the behavioural insight that people are loss averse can be exploited by simple gain/loss framing variations. The behavioural literature shows that individuals are very susceptible to framing and that changing the way we frame options and outcomes can affect individuals' decisions. An outcome of the project will be a clearer understanding of what type of framing most effectively

facilitates a behavioural shift towards more efficient water usage and whether it is helpful to make the link between metrics like 'litres used and not used' and 'financial cost and saving' very explicit. Given that these are low-cost interventions, the results from this proposed experiment (for example how to frame messages to consumers) can be incorporated in existing and future information-provision and environmental-awareness campaigns.

Estimated cost: R642 537
Expected term: 2014-2017

Programme 3: Innovative management arrangements – Rural water supply

Dealing with land tenure and tenancy challenges in water and sanitation services delivery in South Africa: Policy options and opportunities

University of the Western Cape

No. 2358

Amid rapid urbanization in South Africa, the challenges of tenure and tenancy seem to detract from the efficacy of on-going efforts to improve access to urban water and sanitation services for the urban poor and marginalized. The proportion of people without sustainable access to safe drinking water and basic sanitation, a significant proportion of people living under complex mixes of formal and informal tenure arrangements in low- and middle-income areas, continue to cope with water insecurity or express dissatisfaction about water and sanitation service. Although there is a paucity of reliable data on the burgeoning of populations in urban informal economies and, therefore, achievements in access to water and sanitation, it is plausible that this growth may have exacerbated service delivery backlogs and probably reversed some of the gains made towards progressive realization of the access right to water and sanitation. Challenges such as these underscore the need for in-depth review, empirical and action research to develop clear understanding of the ways in which tenure and tenancy affect access to water and sanitation services, particularly for the urban poor, informal tenants and informal settlement dwellers, whose needs for improved services tend to be greater than those of other groups of people living in urban areas. Some of the pertinent research questions are: How is the mix of land tenure and tenancy arrangements within and/or outside the ambit of the formal land registry system characterised, and what is its effect on access to and provision of water and sanitation services. To what extent do current pro-poor service provision strategies take differences in tenure and tenancy profiles into account? How do tenure security and tenancy arrangements affect patterns of access to and investments in water and sanitation services? What are the appropriate service models for different tenure and tenancy profiles? What is the role of formal and informal service providers in this regard, and how can stakeholders, such as the state, non-governmental organizations (NGOs), civil society organisations (CSOs) and the private sector, support this? In the context of rapid urbanization, clear understanding of complexities associated with the mix of formal and informal tenure and tenancy challenges will contribute to enhancing institutional preparedness and mechanisms to improve access to water and sanitation by the urban poor,

marginalized and vulnerable living in low- and middle-income areas. Ultimately, the impacts of this should be social integration, as opposed to fragmentation, as well as better quality of life, dignity, affirmation, enhanced social capacity and well-being.

Estimated cost: R1 890 000
Expected term: 2014-2017

Programme 4: Regulation of water services

Extending performance monitoring and analysis in South Africa

Nelson Mandela Metropolitan University

No. 2359

There is much that has been achieved in the monitoring of municipal service performance through Blue Drop and Green Drop ratings. It is also being demonstrated in WRC Project K5/2118 (ongoing) that relative efficiency can also readily be monitored and cost-efficiency indices calculated by applying stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The initial findings of relative efficiency analysis for a significant sample of South African municipalities were presented for the first time at a WRC-SALGA National Seminar. At this seminar a number of challenges were raised about the relative efficiency monitoring. This proposal motivates addressing selected challenges as well as adding in to overall performance assessment a measure for rating consumer satisfaction. Many have expressed concerns with all forms of performance monitoring in South Africa on the grounds that the data is unreliable. Specifically with respect to relative efficiency benchmarking the concern is that the water service outputs reported were less than what was really being delivered, for instance, that large chunks of the service were, in fact, not operational for substantial periods and that this inflated efficiency ratings. In order to address this concern and preserve the integrity of the results, some form of data audit is required. All of the current performance ratings applied or proposed are supply-side ones. The demand-side ratings are missing in South African municipal water service performance assessment. This shortcoming can be addressed through a consumer satisfaction rating, capable of assessing different components/attributes of the service and likely to be relatively immune to strategic bias and political and bureaucratic manipulation.

Estimated cost: R850 000
Expected term: 2014-2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Establishing the current practice and prospective management strategies for water treatment residues handling, disposal and reuse in South Africa

Umgeni Water

No. 2361

The increasing demand for potable water has led to increased sludge production, which has led to WTRs becoming of increasing environmental and financial concern. Historically, there have been numerous WTR management practices utilised internationally including

disposal through discharge to sanitary sewers, streams or similar bodies of water, landfill (onsite or off-site) and land application (agriculture, forestry and land reclamation), which is the practice most utilised in South Africa. These management methods have recently been questioned due to possible risks to both public health and aquatic life. With continuous WTR production it has become apparent that there is a need for the development of new and improved WTR utilization and disposal technologies that will be sustainable in the long term. Thus the aim of this study is to investigate alternate options for WTR recycling/reuse under South African conditions as well as to determine the changes needed to optimise and secure recycling opportunities. This study will provide guidance on the cost and economy of scale applicable to specific WTR management practices as well as suitability for recycling/reuse. It will also provide recommended actions and changes needed to optimise and secure WTR recycling opportunities. The most cost-effective method of management for the different WTRs will be suggested, potentially saving water treatment plants costs and bringing down the production cost of potable water.

Estimated cost: R1 000 000
Expected term: 2014-2016

Green synthesis and demonstration of a low-pressure low-fouling mixed matrix nanofiltration system for drinking water treatment

University of Johannesburg

No. 2362

The fabrication of novel nanoporous polymers and membranes from polymer nanostructures (e.g. cyclodextrins, polysulfone, polyvinylidene fluoride, and cellulose acetate) has been extensively explored. Most of the studies involved exploring mixed matrices (composites) of the polymers that contained nanomaterials (e.g. carbon nanotubes, silver nanoparticles, iron-nickel nanoparticles, etc), which sought to improve the mechanical strength, hydrophilicity, anti-fouling properties and pollutant rejection capacities of the nanocomposites. In this proposed study, an integrated nanofiltration membrane/composite system that has the complementary strength of ceramics and polymeric membranes, i.e., a membrane material with the high thermal, chemical, and mechanical stability observed with ceramic membranes, while retaining the ease of manufacturing, high packing density, and favourable economics of polymer-based membranes, will be synthesized. Such systems can play a crucial role in purifying water in rural settlements in South Africa, wherein hundreds of thousands of households still rely on river and borehole water for drinking and cooking purposes. The proposed integrated (mixed matrix) membrane/composite nanofiltration system will be synthesized by applying the 12 principles of green chemistry and engineering.

Estimated cost: R915 000
Expected term: 2014-2017

Development and testing of novel metal-modified natural clay-based adsorbents for groundwater defluoridation

University of Venda

No. 2363

Groundwater is the most appropriate and widely used source of drinking water for many rural communities in South Africa. However, the presence of fluoride

concentrations above the recommended limits for drinking water requires defluoridation. A number of methods for removing fluoride from groundwater have been developed, including chemical precipitation, membrane processes, adsorption and ion exchange. Of all these technologies developed so far, adsorption has been considered as the most efficient and applicable technology for fluoride removal from ground and surface water in rural areas. In this study, the development and testing of new or modified adsorbents using locally-available adsorbents with improved fluoride uptake properties, to meet the stringent legislative requirements of 1.5 mg/L of fluoride in drinking water, is explored. The use of locally-available adsorbents for evaluation and application as adsorbents for point-of-use water defluoridation systems for rural areas is a sustainable solution. The potential application of bentonite clay and diatomaceous earth modified with selected high charge density cations such as Fe^{3+}, Al^{3+} and Mn^{2+}, introduced as metal cations, metal hydroxides/oxy-hydroxides or metal oxides will be tested.

Estimated cost: R690 000
Expected term: 2014-2017

Degradation of emerging micropollutants by combined advanced oxidation with immobilized plasmon titanium dioxide nanocomposites in an electrohydraulic discharge reactor

University of the Western Cape
No. 2364

The pharmaceuticals and hormones which are generally produced to accelerate physiological responses in humans are now regarded as a potential threat due to their inherent lipophilic nature and potential to harm human health. Human exposure to PPCPs/EDCs equally has been shown to result in testicular, breast and ovarian cancers, low sperm count and retarded fertility. Electrohydraulic plasma discharge is a novel water-cleaning technology which has recently gained research interest, mainly due to its high efficiency, high speed, and zero or less chemicals needed. This technology involves chemical-free degradation and mineralization of emerging micro-pollutants and microbes which is essential to maintaining public health. Recent studies supported by the WRC at UWC have proved the concept of the advanced oxidation process coupled with a photocatalyst and several patents have been filed. Hence, the aim of this study is to further develop the understanding and application of this new emerging technology to tackle the problem of PPCPs/EDCs in our aquatic environment and water systems, in order to preserve the natural aquatic environment and maintain sound human health. The present study investigates outstanding issues with regards to the novel integration of the plasmonic photocatalyst into the advanced oxidation system. Combining plasmon-enhanced photocatalytic material such as semiconductor TiO_2 with electrohydraulic discharge reactor in an advanced oxidation system, as is proposed in this study, would enhance the photocatalytic oxidation efficiency of PPCPs/EDCs/antiscalants because the reaction would be accelerated by both the high-energy plasma species and the UV emission as well as the plasmon-enhanced photocatalyst.

Estimated cost: R787 400
Expected term: 2014-2017

Functionalized electrospun and cast nanocomposites for the removal of organic matter and bacteria from surface water

University of Johannesburg

No. 2365

Water pollution is a persistent global problem that emanates from increased anthropogenic effects. Polluted water usually contains bacteria, viruses, protozoa, minerals, organic matter and many pollutants in quantities beyond the acceptable limits of water quality standards, therefore requiring treatment before use. Water may be treated using different approaches, depending on the quality of the raw water which enters the plant. Traditionally, adsorbents are used; however, the majority of these suffer drawbacks such as poor pollutant binding capacity as well as weak mechanical strength. In addition, some of these sorbent materials are prone to degradation by chlorine. This study is aimed at the development and evaluation of the potential of fabricated filters for removing organics, metals and micro-organisms from contaminated water. The proposed filters will have functional multi-layers of electrospun fibers impregnated with nanoparticle catalysts to form nanocomposite filters or membranes. The nanocomposites will be cast onto membranes to produce strong support materials with tailor-made porosity to ensure no passage of water contaminants. This is necessary as the small contaminant moieties that normally resist conventional treatment can be effectively removed because of the functional groups that act as binding sites for contaminants. Owing to their small diameters, high surface area to volume ratio and low porosity, these nanocomposite filters are very efficient in removing most of the water contaminants. The significance of this study will be the ease of use of the multi-layered nanocomposites as well as the disinfection of water without addition of harmful chemicals such as chlorine or labile aluminium.

Estimated cost: R650 000
Expected term: 2014-2017

Programme 2: Water treatment for rural communities

Application of high-throughput green liver systems for sustainable water purification using endemic aquatic macrophytes

Nelson Mandela Metropolitan University

No. 2367

This study investigates the development and use of a low-technology, low-maintenance and low-cost biological system based on the 'green liver system' for the treatment of xenobiotics in raw waters, either at source or prior to abstraction. The green liver system is not a new concept; it has been successfully implemented in China and Brazil. In this study selected endemic aquatic macrophytes will be evaluated, in various combinations and ratios, in a sequential exposure model, for their ability to bioaccumulate and/or biotransform environmental toxins and xenobiotics, and selected as components of the green liver consortium. The optimized model system will be further evaluated for tolerance to physicochemical and flow rate variation, and pollutant load. The proposed system should also be suitable for purification of an impoundment in situ. The use of this system has several advantages: it prevents damage to the biological component from grazing or other land use, the biological

consortium can be purpose designed for the particular pollutants, and the addition of a fuel pellet production component encourages harvesting and maintenance of the green liver system. Such benefits do not exist in traditional ponding or wetland systems. The limited successes of wetland systems is largely due to the very large footprint, limited flow, inability to easily manipulate populations for specific desired xenobiotics, and the eventual bioaccumulation of the xenobiotics within the system.

Estimated cost: R450 000
Expected term: 2014-2017

Design, construction and monitoring of a sustainable domestic rainwater harvesting multi- tank treatment station at a central location in Enkanini informal settlement, Stellenbosch

Stellenbosch University

No. 2368

The provision of a continuous and sustainable water source to rural and informal communities is a priority identified by the Department of Water and Sanitation (Department of Water and Sanitation). Domestic rainwater harvesting (DRWH) can be promoted as a core adaptation strategy and has been earmarked as a short-term intervention to provide water, especially to dispersed settlement areas. Numerous DRWH tanks have been implemented by the Department of Water and Sanitation, in eight provinces, as an alternative water supply and for food production. However, a previous WRC study has shown that possible health risks associated with the consumption of harvested rainwater can hamper the large-scale implementation of DRWH, as microbial and chemical contaminants have previously been detected in rainwater tanks. Thus in this study it envisaged that the design, construction and monitoring of a sustainable domestic rainwater harvesting multi-tank station, with on-site treatment systems (based on the results obtained from the pilot scale deliverable for the WRC research project K5 2124 3) will not only alleviate stress placed on the standpipe municipal systems, but will also produce water for domestic and potable purposes, based on the level of treatment provided per respective tank. Furthermore, a pamphlet (Xhosa, English and Afrikaans) containing general information on domestic rainwater harvesting, the identified primary uses per tank and advice on water storage will be developed for the users. Community members will also be trained on major and continuous maintenance and repair of the DRWH tanks and treatment systems using a compiled manual. The operational sustainability and the capacity of the tanks to service numerous households' daily water needs will also be monitored.

Estimated cost: R900 000
Expected term: 2014-2017

Programme 3: Drinking water quality

Extending EDC Toolbox I to include thyroid and androgenic bioassays

University of Pretoria; Griffith University

No. 2303

Project aims:

- To participate in the Global Water Research Coalition EDC Toolbox

- Inter-laboratory study to establish the suitability and application of the thyroid and androgenic bioassays for the detection of EDC activity in water samples

Estimated cost: R430 000
Expected term: 2014-2016

Emerging contaminants in wastewater treated for direct potable re-use: the human health risk priorities in South Africa

Chris Swartz Water Utilisation Engineers
No. 2369

The use of treated wastewater for direct potable applications can play an integral role in meeting future water demands. However, the possible presence of emerging contaminants in reclaimed municipal wastewater is of critical concern because of potential adverse impacts to human health. Specific health effects criteria in the evaluation of water recycling for human consumption include (i) primary health concerns of wastewater reuse that are the long-term health outcomes of ingesting chemical contaminants found in recycled water, (ii) health risks of using recycled water as a potable water supply compared to similar risk for conventional water supplies, and (iii) the need for extensive toxicity monitoring programmes. Much research has been done in Southern Africa and overseas on water reuse. However, to date there are no guidelines on reuse for the South African water sector. This project will therefore be limited to identifying emerging contaminants of concern in reclaimed potable water, their sources, pathways and receptors, potential risk from exposure to these chemicals, performance of water reclamation treatment systems and risks for potable water reuse in South Africa. Assessment of direct potable reuse systems in South Africa for the removal of contaminants that may have negative health impacts will provide a good basis for the development of South African guidelines for implementation of barriers, monitoring programmes and assessment programmes to eliminate or minimise risks and which can improve public acceptance of reclaimed water.

Estimated cost: R1 500 000
Expected term: 2014-2017

Programme 4: Water distribution and distribution systems

State-of-the-art in advanced metering technology and application

University of Cape Town
No. 2370

The water meter industry has seen substantial developments in the last two decades, with many new capabilities added to water meters. These advanced water meters (also called intelligent or smart meters) can be used for much more than just consumption metering. Advanced meters have several significant advantages, such as saving costs by eliminating conventional meter reading, billing and debt management systems; providing simultaneous readings for multiple users allowing more accurate water balance calculations to be done; assisting poor users to manage their free basic allowance; and enhancing water demand management and water loss control. However, advanced metering systems also have important disadvantages, such as a higher failure rates (due to electronics, batteries and more components) than conventional meters; higher supply and maintenance

costs; susceptibility to tampering and vandalism; and concern regarding rights of access to water. It is also a new industry with many teething problems that will still have to be addressed. The aim of this project will be to determine the state-of-the art in developments and application of advanced water metering to allow municipalities to understand the available technology and how best to utilise it. The project is focused on how to use advanced water metering in a sustainable way for providing communities with water supply within the bounds of cost of service provision and limited water resources. A major aim of the project is to assist municipalities with information on decision making regarding advanced water metering.

Estimated cost: R1 280 000
Expected term: 2014-2017

The impact of leak–soil interaction on leak development and detection in water distribution systems

University of Cape Town
No. 2371

Leakage from water distribution systems is a worldwide problem, which is likely to intensify as systems age and available water resources are stretched to their limits. Leaks form in all pipe materials, and thus municipalities must have processes to identify and repair new leaks as they form. The simplest way to find a leak is when it is observed or reported after becoming visible above ground. Other leak detection methods include the monitoring of district metering area flow patterns, analysis of the noise emitted by leaks and inspection of the internal pipe surface. A question that hasn't received much research attention is under what conditions a leak will become visible above the ground. Water distribution pipes are typically buried below meters of graded sandy soils that may facilitate water draining away from the surface. In a recent experimental study it was found that even jets directed vertically upward did not penetrate about 30 cm of an ideal soil, while sustaining a pressure of 25 m in the pipe. The work showed that a fluidised zone of soil and water is created on the outside of a leak that is responsible for dissipating the vast majority of the energy of the water jet, thus substantially limiting the leak's ability to reach the soil surface. Another implication of the fluidised zone is that the high velocities of the soil particles may cause scouring of the outer pipe surface, especially in pipe materials that don't have much abrasion resistance, such as PVC. Evidence of such scouring has emerged from failed pipe samples taken from the field, showing that the pipe material is removed by the soil action, eventually increasing the size of the leak. This may cause even small leaks in PVC pipes to eventually become major problems; however, very little research has been done on this phenomenon. Thus this study will develop an understanding of the fluidisation phenomenon outside leaks in water distribution pipes, and its implications for the development and discoverability of leaks. While the longer-term goal of this work is to develop a theoretical model for the fluidisation phenomenon based on the fundamentals of fluid mechanics, the aim of this project will be to investigate the direct impact on leakage in water distribution systems.

Estimated cost: R700 000
Expected term: 2014-2016

The effect of age on the friction of large-diameter potable water cement mortar-lined pipelines

University of KwaZulu-Natal (Howard College Campus)

No. 2372

Most of Umgeni Water's large diameter potable water pipelines are constructed from steel with a cement mortar lining. Potable water which passes through these pipelines is, in some instances, treated with chlorine and in others with chloramine. In undertaking designs of new pipelines an estimate of the pipeline friction factor is used to determine the pressure along pipe routes through the development of hydraulic grade lines. This information is further used to determine appropriate pipeline wall thicknesses and pumping heads. The friction factor used, therefore, has a direct influence on the cost of the infrastructure that will be implemented. Studies have been undertaken internationally as well as in South Africa to predict how friction of pipelines changes with age. There seems, however, to be limited information relating to friction in cement mortar lined potable water pipelines and how this changes with age. Studies show that biofilm growth on the pipe wall also affects the friction factor. Some researchers have shown a linear relationship between pipe age and roughness. Other studies contradict this because the biofilm processes such as attachment, growth and detachment are non-linear. The rate at which biofilm grows/detaches are dependent on the concentrations of chlorine and chloramines, thickness, flow velocity and other factors. Studies also demonstrate that if the biomass is algae, then the disinfectant plays a very small role in controlling it. So, it is important in this study to do a detailed analysis of the relationship with disinfectant, biomass growth, and water and pipe age. Accounting for sustainability in pipeline design requires a means to determine the correlation between age and friction in potable water cement mortar lined pipelines which transport either chlorine- or chloramines-treated water. This study will provide support for decision makers to decide pipe sizes to deliver the required quantity of treated water to end users. Appropriate pipe size considerably reduces the cost of a pipeline during the planning and construction phase. Analysis of the factors that influence the pipe roughness will be used to select suitable water supply/treatment practices which directly and/or indirectly minimize head losses for reducing running costs. This analysis also provides knowledge about pipeline maintenance that has economic impact.

Estimated cost: R354 000
Expected term: 2014-2016

Updating WRC water demand management software for latest operating systems

WRP Consulting Engineers (Pty) Ltd

No. 2373

Since the early 1990s, the WRC has been providing support to municipalities throughout South Africa to address leakage and wastage from reticulation systems. South Africa was one of the first countries outside of the UK to embrace the Burst and Background Estimate (BABE) methodology which was initially developed by a number of experts from various UK water companies. The BENCHLEAK model developed in South Africa was created to ensure that South African water utilities had free access to software which would encourage the use of the standard IWA water balance. Once again this was the first model of its type and led to the development of many similar models which were used throughout the

world. The BENCHLEAK model also helped to promote the concept of the Infrastructure Leakage Index (ILI) throughout southern Africa and in turn led to a large-scale study of ILI values for almost 100 systems countrywide. BABE models developed through the WRC include the original BENCHLEAK water balance model which was initially developed as a simple Excel spreadsheet and has now been superseded by the AquaLite Model. The SANFLOW model used to analyse minimum night flows was one of the WRC's most popular downloads due to its ease of use and simple design. The various models continue to operate properly on some Windows operating systems but not on some of the later systems. It is proposed that the software is re-designed where necessary to accommodate the latest Windows operating systems; the possibility of creating an iPad version should also be investigated. The aims are therefore to upgrade the existing models to ensure that they are fully operational on all current platforms and operating systems. In addition, it is proposed to convert SANFLOW, PRESMAC and AquaLite to run on an iPad and create an app so that they can be downloaded worldwide.

Estimated cost: R520 000
Expected term: 2014-2015

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

Urban effluent treatment in a rhizofiltration system

Durban University of Technology; Stellenbosch University; 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

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

Integrating agriculture in designing low-cost sanitation technologies in social housing schemes: a case study of Kwadinabakubo, eThekwini Municipality

University of KwaZulu-Natal (Pietermaritzburg)

No. 2220

The disposal of effluent generated from low-cost sanitation technologies such as the decentralized wastewater treatment systems (DEWATS) still poses challenges to the environment. Such effluent has been shown to contain high concentrations of essential nutrients necessary for crop production. WRC Project K5/2002 demonstrated the capacity of different soils to retain these nutrients from the effluent. Integrating agriculture in the planning and design of low-cost sanitation technologies could provide safe and sustainable mechanisms for disposing of such effluent by retaining the nutrients for crop production and releasing water into hydrological systems. There is no information or any guidelines that could inform town planners and policy makers in designing new social housing developments that can integrate agriculture in the design of low-cost sanitation technologies. This project aims to build on previous work by the Soil Science department at UKZN to generate information on recycling of nutrients from DEWATS technology, which will inform policy makers and town planners in the design of new social housing developments that integrate agriculture.

Estimated cost: R1 880 000
Expected term: 2013-2016

Understanding the mechanistic interactions of engineered nanomaterials (ENMs) with biological treatment systems during wastewater treatment – a case of metal and metal oxide ENMs

CSIR (Pretoria)

No. 2374

To protect human health and promote environmental integrity, research towards understanding ENM interactions with WWTP biological treatment systems is crucial. Such knowledge will be useful in developing treatment technologies suitable for ENM removal from wastewater systems. This study is a continuation of a previous WRC project titled 'Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment

systems (K3/2122/3)'. Whilst the previous project mainly focused on the general fate and behaviour of ENMs in wastewater, this work seeks to generate data and knowledge that elucidates the nature of interactions between the ENMs and the biological treatment system as well as understanding plausible elimination mechanisms for ENMs in WWTPs. The results will constitute critical knowledge necessary in the development of wastewater treatment technologies to deal with contaminants with nanoscale dimensions, so as to protect South African ecosystems. This study will investigate the metal and metal oxide ENMs behaviour in wastewater to evaluate their removal over long-term exposure to wastewater, dissolution behaviour, and bio-sorption behaviour on non-viable and viable aerobic biomass.

Estimated cost: R1 200 000
Expected term: 2014-2015

A feasibility study to evaluate the potential of using WSD design principles to strengthen planning for water-sensitive cities of the future

City of Cape Town; University of the Western Cape
No. 2412

Project aims:

- Conduct a scoping exercise to evaluate suitable sites for a feasibility assessment study. This exercise will also evaluate the vision, strategy, organisational structure (i.e. planning divisions), resources, budgets and implementation strength of the institutions that may be involved in adopting WSUD
- Engage and share the water-sensitive urban design concept, framework and guidelines with relevant stakeholders and ensure buy-in of stakeholders throughout the project cycle
- Provide a baseline assessment of the selected catchment/s with relevant implementation partner/s
- Set specific WSUD objectives for the selected catchment with realistic design and performance objectives – including a comparative analysis between conventional design and WSUD objectives
- Screen and evaluate the feasibility of the WSUD options within current best planning and management practices, including the selection of appropriate technology options to meet design, cost and performance objectives
- Where possible, develop suitable templates for the various activities and recommend development of new tools or guidelines where gaps in knowledge exist
- Present options to key stakeholders and evaluate the feasibility of the options and the barriers to implementation and document opportunities for future potential demonstration partnerships
- Link knowledge and partnerships to the WRC Community of Practice Programme

Estimated cost: R2 000 000
Expected term: 2014-2017

Development and management of a Water Sensitive Design Community of Practice programme

City of Cape Town; University of the Western Cape
No. 2413

Project aims:

- Scope potential and current water sensitive design (WSD) project opportunities
- Establish project priorities and their potential to be implemented as WSD research projects

- Develop and maintain 'Learning Alliances'
- Scope institutional challenges associated with implementing WSD in the planning and implementing environment
- Strengthen and broaden the WSD researcher base for South Africa
- Develop a WSD project database and website
- Facilitate and coordinate partnerships with relevant sector players to convert potential WSD projects to demonstration projects for consideration by the WRC
- Consolidate WSD project information from additional research projects

Estimated cost: R2 500 000
Expected term: 2014-2019

Programme 2: Application of appropriate technologies and tools

Nutrient and energy recovery from sewage: demo-researching an integrated approach

University of Cape Town

No. 2218

Humans produce a significant amount of sewage, containing large quantities of nutrients (phosphates, nitrates and micro-nutrients). For example, humans typically excrete 1.6 to 1.7 g phosphorus per day, most of which (approximately 60%) is found in urine. Considering that natural phosphorus reserves are on the decline and are expected to be depleted by 2033, the use of sewage waste has the potential to be a major source of new phosphorus. An alternative technology that utilises seeded electrochemical precipitation (SEP) has the potential to increase the yield and process efficiency of struvite recovery. The use of SEP has been investigated for the removal of calcium carbonate by Hasson and co-workers. This technique has not yet been applied to struvite precipitation, thus providing the opportunity for a novel nutrient-recovery technique. The first aim will be to investigate current nutrient- and energy-recovery technologies based on a systems approach to technology sustainability assessment, which will focus specifically on situation analysis and technology review, in which the analysis of nutrient flows, expected nutrient supply limitations and emerging organic food production will be examined. The second aim will be achieved by investigating the use of seeded electrochemical precipitation as a means to produce struvite crystals of a similar or better quality and size when compared to conventional precipitation techniques.

Estimated cost: R1 426 987
Expected term: 2013-2016

The Activated Sludge Bios – a real-time tool to evaluate activated sludge process performance

Durban University of Technology

No. 2376

The activated sludge (AS) process is an internationally acclaimed method for wastewater treatment, due to its environmental friendliness and economic feasibility. This biologically driven process could only be realised through the advent of engineered systems, which are designed to exploit naturally occurring biological activities. In these

systems, notable interactions are apparent between functional microbial organisms, process configurations and overall operational control, all of which ultimately affect the absolute performance and efficiency of the AS process. For effective management and optimization of the activated sludge process, it is imperative to have a thorough understanding of the possible interactions between the functional microbial organisms and process operations. To date, very little research has been conducted on correlating the dynamics of all functional microbial populations with the works operational conditions and process configurations, worldwide. From previous observations, it was clearly noted that a gap exists in the promulgation of knowledge between various groups in the wastewater community, which subsequently negates a thorough, holistic evaluation of works process performances and thus consistencies. The invaluable information and data generated in the previous project could therefore be used as a basis to expand the current research and to create an easily accessible information source. This study will focus on evaluating a greater number of works including both domestic and industrial WWTW. The overall aim is therefore to develop an interactive web-based tool. This new tool is envisaged to incorporate the current troubleshooting guide and complement it with an interactive, online information hub that establishes a self-sustaining network between wastewater engineers, microbiologists, works operators and the wastewater community at large.

Estimated cost: R1 600 000
Expected term: 2014-2015

Programme 3: Stormwater and sewerage systems

A functional description of urban effluent treatment in a rhizofiltration system

Stellenbosch University

No. 2378

The design of the rhizofiltration system potentially offers a sustainable, energy-efficient solution to prevent pollution in South African rivers. Once proven to be successful at a pilot scale, the results may influence policy and decision makers on water boards and in local governments to suggest the construction of full-scale rhizofiltration systems at strategic locations. Also, the design is such that once proved to be successful at a pilot scale, the construction and upkeep of full-scale rhizofiltration systems can be conducted by unschooled workers from informal settlements along river banks. These communities could therefore be empowered to reduce pollution in their rivers. It is envisaged that the project will ultimately lead to the development of a conceptual model that can be used to guide experimental work and eventually the design of full-scale rhizofiltration systems, as well as better understanding of microbial, physical and chemical interactions within a rhizofiltration system.

Estimated cost: R749 200
Expected term: 2014-2015

Sanitation technology assessment and evaluation

Partners in Development (Pty) Ltd

No. 2414

Project aims:

- Develop a sanitation technology assessment & evaluation tool
- Produce a collection of informative sanitation technology dossiers
- Produce a dialogue report to inform future sanitation policy
- Host knowledge dissemination workshops to present the assessment tool to key stakeholders

Estimated cost: R1 315 600
Expected term: 2014-2015

Programme 4: Wastewater sludge and faecal sludge management

Development of the Anaerobic Digestion and Pasteurisation Treatment (ADAPT) concept for the safe disposal and beneficiation of faecal sludge

Rhodes University

No. 2306

Project aims:

- Establish the functional components of an ADAPT unit (anaerobic digester and pasteuriser) at a sewage works to demonstrate the practicality of this system to treat faecal sludge and generate a pathogen-free effluent
- Understand the biological processes that take place in the anaerobic digester and how it affects the operation of the ADAPT unit
- Test the effectiveness of pasteurisation to generate a pathogen-free effluent suitable for use as a fertiliser for horticulture and crop plants

Estimated cost: R1 180 000
Expected term: 2013-2015

Towards integrated sanitation and organic waste management – improving faecal sludge management on municipal level by upgrading local wastewater treatment plant with value-added processes (example: Tlokwe Local Municipality)

North-West University (Potchefstroom)

No. 2307

The proposed study aims to apply some of the lessons from the iPit study and apply it to peri-urban settlements in Tklowe. In particular, the project teams intends to use anaerobic technology to treat faecal sludge with and without additional organic substrates and by upgrading the current digester at the local wastewater plant to treat faecal sludge – the current digester is being operated without a lid with no biogas harvesting. Laboratory-scale studies will also be conducted using faecal sludge as the main feedstock and the performance evaluated at different loading rates for process optimisation. The project team will draw upon previous experiences in the iPit project to optimise digester performance for faecal sludge (SRT – 20 h). The iPit toilet design will not be field tested in this study but could be at later stage should the proposed project be up-scaled. The Tlokwe Municipality is eager to improve the performance of the local wastewater treatment plant. Their outstanding achievements within the Green Drop assessment and long-standing collaboration with NWU prove their commitment to continuously advance

technology and skills at their facilities. Therefore this project aims to implement a best-practice example at Tlokwe WWTP, making the treatment plant a valuable asset to the community: a resource source instead of a waste disposal plant. This will result in direct economic and environmental and health benefits. The plant's energy-efficiency will increase and methane emissions will be reduced, sources for water pollution contained and an additional renewable energy resource (biogas) will be utilized.

Estimated cost: R1 050 000
Expected term: 2013-2015

Investigating the practice of open defecation post sanitation provision and the practice and implications of ingesting soil which may be contaminated

Partners in Development (Pty) Ltd

No. 2379

The assumption that open defecation ends where toilets begin is faulty. The provision of toilets – as basic sanitation – is a top priority on national and international agendas, and the reason for this is that without toilets people defecate in the open and the faecal contamination of the environment that results is responsible for tragic and preventable death and disease. While the diarrhoeal diseases responsible for a high number of deaths among young children and vulnerable persons receive the most attention, open defecation is also a virtually sure route for the spread of helminthic infections which interfere with growth and cognitive development and impede educational and vocational aspirations. However, while the focus on the provision of toilets to all is an important strategy in the fight to eradicate open defecation, the flawed assumption can be found in many of the campaigns and reports produced by organisations promoting improved sanitation that the provision of toilets can be more or less equated with the eradication of open defecation. Literature investigating open defecation as a preference over using a toilet is scanty. The few reports that do explore this are not specific to the South African context and cultural factors which drive the practice do not always carry from one context to another. This study will investigate the extent to which open defecation continues to occur after the provision of sanitation and document the knowledge, beliefs, motivations, behaviours and attitudes around it in order to obtain the information needed to inform sanitation, health, education and housing interventions.

Estimated cost: R750 000
Expected term: 2014-2015

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

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

Energy generation using low-head hydro technologies

University of Pretoria

No. 2219

Energy is the lifeblood of worldwide economic and social development. When considering the current status of global energy shortages, the emphasis to reduce CO_2 emissions, development of alternative energy generation methods and growing energy consumption, it is clear that there is a need to change the way energy is created and used. Energy experts say South Africa has moderate hydroelectric potential, and that the establishment of small hydroelectric projects around the country could help provide a sustainable future energy supply. The US Department of Energy estimates that there are 6 000 to 8 000 potential sites in South Africa suitable for small hydro-utilisation below 100 megawatts, with the provinces of KwaZulu-Natal and the Eastern Cape offering the best prospects. This project therefore aims to:

- Review the feasibility of generating energy in low-head systems
- Develop guidelines to identify locations where low-head hydropower generation systems can be installed
- Develop an assessment model including a cost–benefit tool

- Demonstrate the technology by means of pilot-plant installations, testing different turbine technologies
- Provision of educational material to illustrate and describe the process.

Estimated cost: R500 000
Expected term: 2013-2015

Towards wastewater biorefineries: integrated bioreactor and process design for combined water treatment and resource productivity

University of Cape Town

No. 2380

This project is focused on development of sustainable process solutions for water-sensitive systems in which water treatment is coupled to value creation – for improved bioresource productivity and a reduced environmental footprint. The project drives towards the integration of production of the clean-water product and that of the C, N and P-based products, by conversion of the organic fractions and salts from the wastewater treated. Specifically this integrated biorefinery system requires effective design of its reactor components to ensure simple and energy-efficient processes. To achieve this requires a cross-cutting and interdisciplinary approach. Further it requires the research approach to be sensitive to the 'big picture' informed by industrial metabolism, while delivering the detailed technical knowledge of individual unit operations, requiring an integrated team approach. The project has potential to contribute towards the empowerment of communities.

Estimated cost: R600 000
Expected term: 2014-2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Evaluation of forward osmosis technology for the treatment of concentrated brines

University of KwaZulu-Natal (Durban); Sasol

No. 2101

The aim of this project was to evaluate the feasibility of using FO for the concentration of high ionic strength wastewaters within Sasol, as a way of reducing costs associated with disposal of brines generated from desalination technologies. The use of FO was based on the technology's cost effectiveness. Unlike pressure and thermal driven processes, FO requires minimal external energy input, mainly for liquid circulation. Other advantages include low fouling tendency, minimal pre-treatment of the feed, reduced cake layer formation which simplifies membrane cleaning, potentially high water recovery and low pressure operation which simplifies design and equipment used. The specific objectives of the study included:

- Evaluating the advantages, limitations and feasibility of using the forward osmosis technology to concentrate various high ionic strength wastewaters within Sasol
- Assessing the fouling characteristics of FO on various high ionic strength industrial streams which are characteristic of having high fouling and/or scaling potential

The study was divided into preliminary and synthetic studies. The study provided fundamental understanding of the application of FO for the concentration of high ionic strength wastewaters within Sasol as well as identifying the limitations associated with such applications, particularly the need for an ideal draw solution and appropriate membrane.

Estimated cost: R354 000
Expected term: 2011-2014

Integrated bioremediation and beneficiation of bio-based waste streams

Rhodes University

No. 2225

An integrated approach (ReBenFruWaste) for the remediation of fruit waste streams with high organic loadings with simultaneous beneficiation through the production of valuable products is proposed. The integrated approach will be evaluated on existing food waste streams, but could lay the foundation for the treatment and beneficiation of biorefinery waste streams when bioeconomies come to fruition. This project has four main aims:

- Analysis of existing food waste streams (fruit and olive mill waste streams) for sugar, lipid, phenolic and lignocellulosic content
- Bench-scale fermentations to evaluate (i) conversion of high sugar streams to ethanol (renewable fuel) and (ii) utilization of high streams with high lipid, phenolic and lignocellulosic content as feedstock for high-value enzyme production by *Aspergillus niger* strains
- Characterization of enzyme production and bench-scale demonstration of enzyme applications in different bioconversion processes, from lignocellulose conversion, treatment of resilient phenolic waste streams to the production of valuable fine chemicals, such as antioxidants
- Final cleaning of remaining waste streams through anaerobic digestion (can be combined with municipal waste treatment)

Estimated cost: R750 000
Expected term: 2013-2016

Programme 3: Quantification, prediction and minimisation of water use and waste production

Using membrane distillation crystallization for the treatment of industrial wastewater

University of Cape Town

No. 2223

The sustainable treatment of acid mine drainage and industrial wastewaters is necessary if sustainable growth and responsible management of water is to be achieved in South Africa. Membrane distillation crystallization offers a sustainable wastewater treatment process because it can utilise excess heat from processes, and produce pure water as well as salt(s) products, thus converting waste material into something of value. Membrane distillation crystallization is also an attractive wastewater treatment technique because it requires low operating temperatures (40-60°C); the hydrostatic pressure encountered in the process is lower than in reverse osmosis and less expensive material such as plastics can be used in the process. Another major advantage of MDC to the application of AMD is that the process is able to operate in very acidic or basic streams and thus the AMD

streams would not need to be pre-treated or neutralized beforehand. This project therefore aims to investigate the applicability of MDC for the treatment of industrial wastewater, with a specific focus on the treatment of mine wastewater. The project also aims to contribute to the field by investigating concentration polarisation and its effect on the process, while at the same time developing better crystallizer control strategies. Ultimately, this project could offer a more energy-efficient and sustainable industrial wastewater treatment process that reduces wastewater production.

Estimated cost: R1 400 000
Expected term: 2013-2016

Revision of Natsurv 4: Water and Wastewater Management in the Dairy Industry (Edition 2)

University of KwaZulu-Natal (Pietermaritzburg)
No. 2226

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However, South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 4: Water and Wastewater Management in the Dairy Industry' and documents water and wastewater management within the dairy industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Estimated cost: R700 000
Expected term: 2013-2015

Long-term forecasts of water usage for electricity generation: South Africa 2030

Quantitative Evidence Research cc
No. 2383

Water and energy are key resources required for social and economic wellbeing and both are increasingly scarce. Extracting, delivering and disposing of water requires energy and extracting and refining fuels and producing electricity requires water. This water–energy nexus is becoming increasingly important due to increasing energy demands and decreasing freshwater supplies. While it is estimated that power plants account for approximately half the global industrial water withdrawal, limited studies have investigated the water–energy nexus in South Africa. The aspect of water usage becomes critical when taking into account the state of water scarcity. The objective of this project is to fill this knowledge gap and identify current water requirements for electricity production currently, and, based on future electricity demand projections, to develop conditional forecasts for the demand on water supplies. This work will be important for water and energy policy development.

Estimated cost: R306 000
Expected term: 2014-2015

Revision of Natsurv 5: Water and Wastewater Management in the Sorghum and Beer Industry (Edition 2)

CSIR

No. 2384

The Natsurv reports of the different industries have been well used by the sector. However, South African industrial sectors have either grown or in some cases shrunk considerably since the first editions were published, in the 1980s. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. This project will review Natsurv 5: Water and Wastewater Management in the Malt Brewing Industry, since industrial production of sorghum beer has increased over the last 20 years, and, malting sorghum for traditional beer brewing has developed significantly into a large-scale commercial industry.

Estimated cost: R700 000
Expected term: 2014-2015

Revision of Natsurv 6: Water and Wastewater Management in the Edible Oil Industry (Edition 2)

Chris Swartz Water Utilisation Engineers

No. 2404

Project aims:

- To review and document water and wastewater management within the edible oil industry as part of the first stage of revisions of the Natsurv series 1 to 16
- Provide a general overview of the edible oil industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes
- Determine the water consumption and specific water intake (local and global targets and benchmarks)
- Determine the wastewater generation and typical pollutant loads
- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14 000 to name a few
- Provide recommendations for best practice

Estimated cost: R750 000
Expected term: 2014-2016

Revision of Natsurv 8: Water and Wastewater Management in the Laundry Industry (Edition 2)

Cape Peninsula University of Technology

No. 2405

Project aims:

- To review and document water and wastewater management within the laundry industry
- Provide a general overview of the laundry industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes
- Determine the water consumption and specific water intake (local and global targets; benchmarks).
- Determine the wastewater generation and typical pollutant loads

- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life-cycle assessments, water footprints, and ISO 14 000, to name a few
- Provide recommendations for best practice

Estimated cost: R700 000
Expected term: 2014-2016

Revision of Natsurv 12: Water and Wastewater Management in the Pulp and Paper Industry (Edition 2)

Prodomos Technologies (Pty) Ltd

No. 2421

Project aims:

- Provide a detailed overview of the pulp and paper industry in South Africa, its changes since 1980 and its projected change(s). Representative samples of the respective industries will be used as case studies.
- Critically evaluate and document the 'generic' industrial processes of the pulp and paper industry in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critically evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name a few. Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution.
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000
Expected term: 2014-2016

Revision of Natsurv 17: Water and Wastewater Management in the Steel Industry (edition 1)

Prodomos Technologies (Pty) Ltd

No. 2422

Project aims:

- Provide a detailed overview of the steel industry in South Africa, its changes since 1980 and its projected change(s). Representative samples of the respective industries will be used as case studies.

- Critically evaluate and document the 'generic' industrial processes in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critical evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name a few. Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000
Expected term: 2014-2016

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

Micro-nutrient requirements for anaerobic digestion of concentrated industrial effluents: Development of a speciation/precipitation model to optimise micro-nutrient dose for methane production from industrial waste streams

University of KwaZulu-Natal (Howard College Campus)
No. 2228

Anaerobic digestion of industrial effluents is used to convert organic material at concentrations that are too low for economic recovery to methane gas. Balanced anaerobic digestion requires inorganic micronutrients to proceed. In many industries, including hydrocarbon and certain chemical industries, effluent streams may contain a number of the micronutrients required for balanced growth, but there may be several micro- (and macro-) nutrients that are not present in the stream. To date, research in the field has been predominantly experimental and empirical; there are no studies which provide guidelines for predicting the micronutrient requirements for a particular application beyond the general micronutrient-to-COD ratios. Therefore, this study will test the hypothesis that a model describing the partitioning of micronutrients between soluble, precipitate and potentially bound and adsorbed phases can be used to determine the amount of the micronutrient available for anaerobic digestion, and can therefore be used to predict the microbial response to different micronutrient dosing strategies.

Estimated cost: R400 000
Expected term: 2013-2016

Phase 2: Recovery and beneficiation of nutrients and water from brewery effluent by means of unique combination of algal assimilation, constructed wetlands, hydroponics and aquaculture

University of Cape Town; Rhodes University

No. 2284

Project aims:

- Develop a better understanding of (i) the changes that take place in HRAP algal community structure at different times of year and/or at different flow rates, and (ii) the underlying mechanisms responsible for some of the results obtained in the HRAP during Project K5/2008, such as the mechanism/s responsible for majority of the ammonia and phosphate removal.
- Develop technology to convert brewery effluent grown algal biomass into fish biomass without mechanically harvesting the algae and allowing filter-feeding fish to bioconvert algal biomass into fish biomass

Estimated cost: R850 000
Expected term: 2013-2016

Nanoparticles for the treatment of industrial scale effluents – particularly the removal of organic contaminants from textile effluents using nano-TiO_2

Cape Peninsula University of Technology

No. 2386

Textile production is a water-intensive and potentially highly-polluting activity, and the treatment of textile industry wastewaters is a topic of considerable research. At the same time, engineered nanomaterials for wastewater treatment, immobilized in robust industrial-scale systems, are emerging technologies currently receiving international attention. The aim of this project is to assess some of the emerging nanotechnologies for wastewater treatment to contribute to water and energy savings in the textile industry for sustainable economic development in Southern Africa.

Estimated cost: R1 250 000
Expected term: 2014-2016

The use of modified multi-walled carbon nanotubes for the selective extraction of Cr(VI) and mercury from industrial effluents

University of Johannesburg

No. 2387

Hexavalent chromium) and mercury (both inorganic and organic forms) are two priority pollutants, and although treatment methods such as ion exchange, chemical precipitation and reverse osmosis have been used, adsorption has been identified as a key process in metal ion removal due to its efficiency. Adsorption by activated carbons has been popular for both pollutants. However, activated carbon suffers from disadvantages, such as lack of selectivity for a specific pollutant. Carbon nanotubes are a new form of nanomaterials which have been gaining increasing recognition for their applications in environmental remediation, due to their superior adsorption capabilities to conventional adsorbents like activated carbon. This project therefore aims to investigate the use of carbon nanotubes as selective sorbents for the two metals of interest. The emphasis is on multi-walled carbon nanotubes, since these are cheaper, more easy to

synthesise and more readily available than single-walled carbon nanotubes.

Estimated cost: R1 000 000
Expected term: 2014-2017

Anaerobic and photocatalytic treatment of textile and distillery wastewater in integrated fluidized bed reactors

Vaal University of Technology

No. 2388

The treatment of many industrial wastes requires the application of robust and costly techniques, which is a major deterrent. It is for this reason that biological methods have proved to be very attractive to both industries and local authorities. However, these systems, used as stand-alone techniques, are not efficient in treating some high-strength industrial wastewater. Generally, biological wastewater treatment, especially anaerobic digestion (AD), has been the technique of choice for many years due to its simplicity and low cost, but AD is challenged by the presence of xenobiotic and recalcitrant compounds. Process efficiency and robustness may be improved by integration with another process, such as ion exchange, membrane processes, or advanced oxidation processes. This study will investigate the development of a combined bioreactor/photoreactor and its applicability to common South African industrial wastewaters.

Estimated cost: R1 200 000
Expected term: 2014-2017

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

An industrial ecology approach to sulphide-containing mineral wastes to minimise ARD formation: characterising potential for ARD, design for disposal and extraction of products with value

University of Cape Town

No. 2231

Project aims:

- Develop a method for characterizing the long-term ARD generation potential that takes into account the likely impact of microbial colonization and the relative time frame of acidification and neutralization, building on the proposed concept of the biokinetic test (Hesketh et al., 2010)
- Provide an expanded techno-economic assessment and holistic environmental assessment of the sulphide separation step for removal of risk of ARD formation
- Develop appropriate uses for the benign tailings generated in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden
- Develop appropriate uses for the sulphide-rich tailings resulting from the separations in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden

Estimated cost: R2 565 000
Expected term: 2013-2017

The BioSURE Process: a sustainable, long term treatment option for acid mine drainage treatment

VitaOne8 (Pty) Ltd

No. 2232

The BioSURE Process was identified as one of few treatment options suitable for the treatment of AMD in the Witwatersrand and elsewhere. However, it has been rejected by Aurecon, in their feasibility study for the Witwatersrand, as a viable option for the long-term treatment of AMD, the reason cited being a lack of full or demonstration-scale operating data. The full-scale operation undertaken by the East Rand Water Care Company (ERWAT) has in fact demonstrated that the BioSURE Process can be used as a cost-effective treatment technology for AMD. The process is attractive because it makes use of primary sewage sludge or other sources of organic wastes as substrate and produces a good quality effluent. Since it converts permanent hardness into temporary hardness, conventional cold-lime softening processes can be used to desalinate the water while valuable by-products may be recovered. The effluent quality after desalination is suitable for consumption in various industries as a substitute for high-quality potable water. ERWAT, in its role as a service provider, is very well positioned with its access to sources of primary sewage sludge and biodegradable organic waste. As an operating company and with the past experience of operating a 10ML/day plant, it can play a significant role in the treatment of AMD. A survey of the industries indicated that there are reliable and consistent sources of waste, other than primary sewage sludge, from various industries to treat approximately 20-30 ML/day of AMD in the Central and Eastern Basins. This waste is currently being disposed of in landfill sites at high cost. Considering the quantity of primary sewage sludge generated by ERWAT and Johannesburg Water's wastewater treatment plants that can practically be used, a significant volume of AMD can be treated in the Witwatersrand. Co-treatment with industrial waste and recovering costs for treatment of industrial waste will reduce the overall treatment cost of AMD. It is therefore important that more aspects should be considered than only the need to treat AMD. These aspects include the requirements to treat and dispose of sewage sludge and the urgent need to provide additional capacity to process biodegradable organic solids. This project is required in order to improve the BioSURE Process and to properly document its operating philosophy and limits to applicability, in order to make it truly available for implementation. It is planned to:

- Compare the performance of the biological sulphate-reducing reactors using primary sewage sludge and carbohydrates such as silage and combinations thereof
- Test the performance of the process using a feed of high acidity, low pH AMD
- Investigate the removal of hydrogen sulphide using a process to regenerate iron hydroxide with a biological iron-oxidising process integrated with the recovery of valuable magnesium sulphate using a eutectic freeze unit
- Investigate the integration of the effluent treatment process with the so-called SANI process for COD and nitrogen removal

Estimated cost: R1 557 600
Expected term: 2013-2015

Prevention of acid rock drainage (ARD) formation from fine coal and tailings fractions by sulphide removal: the role of bioflotation reagents

University of Cape Town

No. 2389

UCT has developed an approach to attaining benign tailings and waste materials for disposal from sulphur-containing fine coal fractions, base metal and gold tailings, either at the point of generation or through the re-processing of waste deposits. The separation is based on flotation with the potential for improved resource productivity in addition to acid rock drainage (ARD) prevention. There is a growing body of literature on the use of biological agents as flotation reagents. In this project, we will investigate the use of bioflotation for both the recovery of coal from coal fines and the recovery of pyrite from both coal fines and base metal tailings fractions. Our aim is that, should successful flotation processes be defined, the flotation reagents would be such that they could be manufactured cost effectively on site using waste organic resources in the vicinity of the site of application, thereby removing the transport requirements. Secondly, such reagents would need to meet the specifications of being non-toxic and completely biodegradable.

Estimated cost: R1 247 513
Expected term: 2014-2018

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

Continuous eutectic freeze crystallization

University of Cape Town

No. 2229

While treating coal mining–impacted waters using reverse osmosis, facilities such as the Emalahleni Water Reclamation Plant and the Optimum Water Reclamation Plant produce large volumes of hypersaline brines. These brines are disposed of in evaporation ponds, and thus are lost to the usable water pool. With increasing use of desalination, and hence brine production, the loss of water is predicted to increase exponentially. The total combined brine production rates for the coal and gold mining industries in South Africa are projected to be ±17 000 m^3/day in the next 20 years from current values of ±3 000 m^3/day. Conventional treatment methods, such as concentration in evaporation ponds, have many disadvantages including extensive land use and low productivity. In addition, evaporation ponds recover neither the water nor the salt. Eutectic freeze crystallisation (EFC) is able to reduce the volume of brines by as much as 97% and concurrently produce pure salts as well as potable water. For example, pure calcium sulphate, pure sodium sulphate and potable water, in the form of ice, can be produced. Eutectic freeze crystallisation works on the principle that when brine is cooled to the eutectic temperature, both ice and salt crystallise out of solution. The ice, being less dense than water, will float, and the salt, because it is denser than water, will sink, thus effecting gravity separation. There is a major misconception that any freezing process is expensive but, thermodynamically, it is cheaper to freeze one kilogram of water (333 kJ) than to evaporate one (2 300 kJ). Energy savings of 85% have been reported when comparing EFC to evaporative crystallisation. An extensive experimental programme focussing on the use of EFC has been undertaken over the past 6 years and proven the concept of EFC as a feasible treatment for multi-component hypersaline brines. Firstly, it was shown that thermodynamic modelling can accurately predict the identities of the recovered salts, as well as their recovery temperatures. Secondly, it was shown that EFC can be used for the treatment of hypersaline brines and inorganic effluents produced by major South African industries. Thirdly, it was shown that EFC can be used to recover multiple salts from multicomponent brines. Lastly, it was shown that EFC can produce almost pure salts and ice. However, all of the work so far has been done in batch mode, an essential mode for testing proof of concept and initial feasibility. Although the batch mode has provided crucial information, it has not been sufficient to showcase the potential of the technology. The next challenge is to develop EFC to the point that it can be used in continuous mode. In this project, important knowledge about operational considerations for continuous EFC, including residence time, degree of undercooling, crystalliser solids content and operating limits, will be generated. This knowledge is crucial for making the transition between batch and continuous, as well as to be able to design an EFC plant on both a pilot and industrial scale. This is the essential focus of this project.

Estimated cost: R2 276 600
Expected term: 2013-2018

Improving evaporation rates of mining wastewaters

University of the Western Cape

No. 2390

Coal-mining activities generate wastewater, and the minimization of wastewater, through its reuse, or safe re-entry into the hydrological cycle, is a critical part of water management and integral in tackling water scarcity issues. The resulting wastewater brines are complex liquid mixtures of different salts with a composition that varies depending on the water process system used to produce the final saline effluent. As a result of the large quantities produced and due to its chemical composition, there is a need to properly and safely dispose of the brine solution. Evaporation ponds evolved years ago, and they are still considered the most effective brine management option due to several advantages which include easy construction, low maintenance and little operator attention. Predicting the evaporation rate of the pond is critical in effective management of the brine disposal holding area. This is a concern with increasing salinity due to the large amount of dissolved salts in the ponds, as this results in a decreased rate of evaporation. The consequence of this is the need to build additional ponds, which requires large areas of land. The objective of this study, therefore, is to investigate methods to improve the evaporation rate of brine in ponds using chemical and halophilic biological colouring agents to increase the absorption of insolation.

Estimated cost: R1 795 960
Expected term: 2014-2018

The synthesis of highly selective immobilized ligands for extraction of toxic metal ions from waste water

University of the Western Cape

No. 2391

It was reported by Madzivire et al. (2012) that the concentration of radionuclides in Rand Uranium mine-water was above the target water quality range (TWQR) for potable water set by the Department of Water and Sanitation by a factor of 12. Generally, discharges of radioactive elements such as uranium, thorium and strontium to surface and groundwater originate from anthropogenic sources. Although there are a number of conventional extraction methods that remove radionuclides from water using ligands, in most cases the ligands are destroyed and the metal ions cannot be recovered for re-use. This means new ligands must be produced for each treatment cycle, and the spent ligands carrying the radioactive ions must be disposed of responsibly. The purpose of this project is to develop a method which will enable the recovery of both the ligands and the metal ions so that both can be reused.

Estimated cost: R765 362
Expected term: 2014-2018

An integrated bioprocess for AMD remediation and renewable energy generation

University of Cape Town

No. 2392

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa and is already having a negative impact on the quality of several important water resources. There are two main sources of ARD in South Africa: firstly the rebound of groundwater through underground workings, which typically has a high volume, low pH, high metal and sulphate load and tends to be restricted to a single discharge point, and is suited to active treatment. The second source of ARD is diffuse, such as spoil heaps, waste rock dumps and open pits, whose waters vary substantially in volume and composition, and are more amenable to passive or semi-passive treatment. This research will result in a design for an integrated, sustainable biological process with the ability to treat low to medium volume ARD streams. The potential for energy recovery, both as biogas and electricity, will be assessed.

Estimated cost: R2 372 862
Expected term: 2014-2019

Application of next generation sequencing and metagenomic analysis to characterise mixed microbial communities involved in sulphur metabolism

University of Cape Town

No. 2393

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa. Biological desalination of ARD has been implemented to some extent, but due to a lack of a detailed understanding of the micro-organisms responsible for the process (mainly due to inadequate methods for identifying and quantifying the microbial ecology within the process unit), it has been applied as a 'grey box'. The advent of culture-independent molecular biology techniques has facilitated a more complete assessment of the microbial ecology, and the most recent advances in metagenomics, combined with either transcriptomics or proteomics have opened the way for deep, genomically-resolved analyses of the metabolic potential of microbial consortia. Genome resolution enables a far more complete view of metabolic capacity and functional roles, as well as evolutionary processes, than is possible using datasets with minimal or no assembly and provides the foundation for community proteomic and transcriptomic measurements. Genome reconstruction-based metagenomics analyses will be applied here to biological ARD desalination. Important information on the metabolic potential of component species and the interactions between community members will be derived.

Estimated cost: R1 754 440
Expected term: 2014-2018

Biogeochemical cycle of mercury in natural and manmade wetland ecosystems affected by gold mining and industrial activities in the Witwatersrand Basin – modelling and remediation

University of the Witwatersrand

No. 2394

Wetlands are essential habitats in the environment since they fulfil a variety of ecological functions. One of the major characteristics of wetlands is their ability to act as chemical sinks. Due to this, they tend to accumulate pollutants that are introduced into the environment such as lead, copper, zinc, chromium and mercury. The nature, the level and the impact of mercury in the environment has not been extensively studied in South Africa, particularly in areas that have been significantly affected by mining activities. The reports are mainly from coal combustion and chlor-alkali plants. No seasonal changes and bioaccessibility have been reported. There is therefore a need to carry out a detailed assessment and evaluation of the impact of mercury in Gauteng, an area very densely populated and with intensive water use.

Estimated cost: R950 000
Expected term: 2014-2018

THRUST 6: WATERSMART FUND

An investigation of the treatment efficacy of permeable pavements with a view to harvesting stormwater for use in South Africa

City of Cape Town

No. 2409

Project aims:

- Undertake an investigation of the treatment efficacy of permeable pavements in South Africa with a view to harvesting stormwater for use
- Assess the design and maintenance of existing permeable pavements and make recommendations for improvements where necessary
- Fine-tune the assessment methodology for South African conditions to test the treatment efficacy of other stormwater management technologies / sustainable drainage system (SuDS) technologies in the future
- Develop a database for collecting performance data for different SuDS technologies operating under varying conditions

Estimated cost: R500 000
Expected term: 2014-2016

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Exploring opportunities for domestic-local investment in water and sanitation services – challenges and constraints

African Centre for a Green Economy (Africege); University of Cape Town; University of the Western Cape; Cape Peninsula University of Technology; Crossflow Consulting (Pty) Ltd

No. 2484

Significant effort by the South African government has gone into mobilizing resources to meet service delivery targets. Most of the resources directed to funding water and sanitation infrastructure have come from Government capital grants for new infrastructure and operating grants to support service delivery to poor households and for free basic water. Despite the substantial investments, major backlogs in service delivery still remain in many parts of the country, especially in rural and township areas. This has been compounded by other socio-economic challenges and has given rise to the prevalence of service delivery protests throughout the country, with major implications for the productivity of the South African economy. Many developing country governments and the international development community are looking for ways to accelerate access to improved water and sanitation services beyond the Millennium Development Goal (MDG) targets. Many countries do not have the capacity to meet the need for improved water supplies and sanitation services from public resources alone. This is also the case in South Africa, where the fiscus is the main source of funding and there is great dependency on it to close the backlogs quickly. These challenges present an opportunity for domestic enterprises in these growing markets. The domestic investment sector is increasingly being viewed as a central part of the solution. Effective scale-up of access through the domestic investment sector requires an understanding of the market potential, the state of entrepreneurs' operations, and factors that shape their business environment and investment decisions. This study will examine the investment sector's support to piped water services and sanitation services. It will cover aspects of policy, legislation, constraints and challenges, as well as models to facilitate or enable participation. The outcomes of this project relate directly to the Government's mandate to deliver basic services to its citizenry, in an efficient, inclusive and effective manner, as defined in various policy documents including the Water Services Act and the National Development Plan (NDP).

Estimated cost: R800 000
Expected term: 2015-2017

Programme 2: Institutional and management issues – Water services

Review of urban sanitation in South Africa – challenges and constraints

Palmer Development Group

No. 2486

Almost half of South Africa's population lives in urban areas and their need for safe sanitation and wastewater management services is growing rapidly. Beginning in 2000, the central government embarked on a series of initiatives to reform water supply and sanitation sector policies. These reforms were aligned with decentralization which devolved responsibility for sanitation to the local government. Despite these initiatives, urban sanitation continues to perform inadequately and faces critical issues that need to be urgently addressed. There is a tendency for many planners and designers to wait for large sums of investment, driven by issues of compliance and political pressure, and thus to respond with conventional solutions. Often these are not affordable to the users or the municipalities. A radical new approach is required, incorporating elements of the water–energy–food nexus together with water-sensitive urban design. It is hoped that the review will develop a strategic framework to help guide national urban sanitation programmes and their implementation in growing urban areas. This study aims to provide a review of urban sanitation in South Africa.

Estimated cost: R594 839
Expected term: 2015-2017

Developing innovative approaches to national allocations and transfers to local government

Palmer Development Group

No. 2487

Recently new innovative systems of grants have been experienced in a number of countries, some of these targeting the performance of local government. SALGA, CoGTA, the Presidency and Treasury are currently busy with the review of national allocation and transfers to local government and in the process are trying to establish the effectiveness of the current processes. It is envisaged that this initiative will lead or require the development of new approaches and processes, based on local circumstances and international best practices. This study will build on this progress and establish new mechanisms and solutions.

Estimated cost: R652 800
Expected term: 2015-2017

Assessing the impact of a mobile application in monitoring water consumption and leak detection at household level

University of Cape Town; City of Cape Town

No. 2485

In recent years, demand-side management of water has gained much research interest, mainly because of steadily increasing populations that have driven an increase in demand for our limited freshwater resources. There is a growing recognition that water resource managers must shift their focus from production and supply to finding ways of reducing user demand. In order for water

conservation participation to increase in homes the water users must have easy access to information. Many water users lack knowledge to manage their water demand and are therefore often unable to engage in a discourse with the municipality. Metering is an incentive to engage consumers in water demand management by improving their knowledge about their water consumption. However, it is currently under-utilised in this respect and future research could explore innovative methods to allow consumers to access information about their daily water use. This project intends to assess the impact of a mobile application (called 'Drop Drop') that is designed to allow households to monitor their water consumption by reading their meter and to assist them in leak detection. The application also provides invoice prediction and a simple communication tool to contact the relevant departments in the municipality. The hypothesis is that providing water users with real-time information about their water use increases their ability to monitor consumption and manage their water demand. The investigation will increase the knowledge base on how personalized water supply information can change consumer perceptions of water usage and increase the level of knowledge as well as trust in the billing system. Part of the project will also be to assess how we can develop mobile applications that are immediately usable without extensive training or documentation.

Estimated cost: R500 000
Expected term: 2015-2017

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Solar energy for desalination and water purification

University of Pretoria

No. 2467

Project aims:

- To extend the prior lab testing of the three methods (solar distillation coupled to both a graphitic foam target and a carbon black suspension, as well as a solar evaporator), to small pilot scale, in order to identify possible large scale implementation issues and assess feasibility
- To compare all three methods and determine which is the most efficient and cost effective for desalination/ brackish water recovery
- To determine which of the three methods will result in the design with the lowest maintenance and operator input

Estimated cost: R500 000
Expected term: 2015-2017

Programme 3: Drinking water quality

Nano-membranes hyperbranched polymer integrated system for water remediation

University of Johannesburg; Stellenbosch University

No. 2488

Organic compounds such as chlorinated compounds and phenolic compounds (pesticides) are widespread, mobile, and highly toxic and persistent in the environment. Due to improper disposal and slow degradation rates this has resulted in the accumulation of chlorinated and phenolic organic compounds in the environment. Thus their removal in the environment using treatment methods such as catalytic degradation has become a priority for water treatment industries. Hyperbranched polymers such as hyperbranched polyethyleneimine (HPEI) have a high number of internal amine functional groups, which can act as ligands to complex metal ions such as Cu, Fe, Ag and Ni for nanoparticle synthesis. Secondly, nanocavities in the HPEI structure act as hosts/templates for the preparation of narrow and stable nanoparticles. Moreover the nanocavities can act as catalytic and adsorption sites for the degradation and removal of organic pollutants. The hyperbranched structure of the hyperbranched polyethyleneimine also provides a shell to prevent aggregation of the nanoparticles. Lastly, the highly branched peripheral amine functional groups of the HPEI with the bimetallic nanoparticles can be grafted with other molecules such as cyclodextrins, carbon nanotubes and membranes to prepare a new generation of multifunctional material for advanced water treatment applications. Literature studies confirm that materials composed of hyperbranched polymers have rarely been utilised in water treatment and mainly in medical applications. Thus there is a great need for further research on these materials in order to broaden their application. Therefore, this project will look at crafting a system that is composed of hyperbranched polymers attached to macromolecules such as carbon nanotubes (for mechanical strength) doped with catalysts such as bimetallic nanoparticles (Fe/Ag, Pd/Fe) or enzymes (lignin peroxidise, manganese peroxidise and laccase) for the effective removal of organic contaminants.

Estimated cost: R600 000
Expected term: 2015-2018

Development and evaluation of a Donnan dialysis process for the recovery and reuse of aluminium from potable water treatment residuals

Stellenbosch University; Durban University of Technology; Cape Town Municipality; Umgeni Water

No. 2470

Aluminium salts, particularly aluminium sulphate (alum) are widely used as a coagulant in large-scale potable water treatment, both internationally as well in South Africa. The precipitated solids from these processes are further dewatered in a filter, yielding an aluminium-rich sludge and a water stream that contains a significant concentration of dissolved Al. At present, the sludge invariably ends up on a land-fill/waste-disposal site, and the destination of the dissolved Al is a river or the sea. It would seem obvious that there would be significant benefits to the costs of water treatment plants, the preservation and optimal use of natural resources, and the protection of our environment if Al could be recycled

and reused. However, whilst there have been concerted efforts to do so over many years, the recycle and reuse of Al have proven to be extremely difficult. Donnan dialysis (DD) is a relatively new technology in the water treatment field. DD uses a cation-exchange membrane, i.e., a membrane that will allow only positively-charged ions to pass through but blocks the passage of negatively-charged and un-charged species. In preliminary work on this topic it was demonstrated that DD was capable of selectively recovering Al, without contamination by organics, from a local WTR. From an engineering point of view the next stage in the development and evaluation of this very promising technology would be to determine the important operating variables that affect the performance of Al recovery, determine how these can be optimized, and hence develop a 'regime map' of the feasible operating regime. From this a 'modular' DD cell can be developed, i.e., a cell which can be replicated and stacked in parallel to process the large volumes that would be required from a real recycling process.

Estimated cost: R1 000 000
Expected term: 2015-2018

Programme 4: Water distribution and distribution systems

Diversity and dynamics of the microbial population associated with drinking water distribution networks and their impact on drinking water quality

University of Pretoria; Rand Water; University of Glasgow
No. 2469

Water utilities face major challenges in supplying and maintaining safe drinking water to communities. Water leaving the treatment plant is typically of high quality but conditions within the distribution system often lead to deterioration in water quality. Amongst the quality determinants, the microbial quality of the water is typically impacted the most. It is now widely accepted that such studies have focused on only a limited part of the microbial community, and that both the dominant members and some important pathogens may not have been detected. The recent developments in high-throughput sequencing, e.g. 454/Roche or Illumina, and microarray technologies for community analyses, e.g. PhyloChip, during the past few years have opened the door to investigate microbial communities at both species-level resolution and also quantitatively. The proposed study aims to address the following questions based on data collected for a South African network:

- What is the variation in the microbial community present in a distribution system primarily supplied by treated surface water and can the variation be linked to seasonal factors?
- Is the same correlation between the microbial community in the bulk water and the sand filter community observed in a large distribution network where different types of disinfection are practised at different times?
- How homogenous is the microbial community associated with sand filters?
- Are the bacteria involved in nitrification already present in the bulk water directly after treatment and what factors promote their growth within the system?

It is anticipated that answers to these questions will provide the necessary foundation for the development

of a predictive framework and early warning system to manage the microbial quality of drinking water supplied to consumers.

Estimated cost: R900 000
Expected term: 2015-2018

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Biomimicry wastewater treatment technology – monitoring & evaluation
Isidima Design & Development (Pty) Ltd
No. 2479

The biomimicry approach is based on learning from nature and then emulating nature's forms, processes and systems to solve challenges and create truly sustainable design solutions. Biomimicry South Africa has partnered with John Todd Ecological Design, Informal South, Greenhouse and Maluti Waters to develop innovative ecological technologies (Ecomachines) for treatment of wastewater streams in informal settlements. To date, two rounds of design work addressing the issue of highly concentrated greywater flowing out of two informal settlements in the Western Cape region has been completed. However, the application of these systems in informal settlements as innovative prototypes for treating wastewater (and managing stormwater) requires careful monitoring of the different components of the systems and how they evolve over time, as well as the water quality. To ensure successful implementation of Ecomachine design and also to inform further designs, a research programme for monitoring and evaluating these Ecomachines is required. In this regard, three design solutions based on an ecological treatment system will be implemented, monitored and evaluated. The monitoring and evaluation of floral and faunal responses and succession over time, as well as the impact on water quality will therefore be conducted.

Estimated cost: R500 000
Expected term: 2015-2017

Programme 2: Application of appropriate technologies and tools

Best practices in sustainable water and wastewater management: a road map to Green Drop and Blue Drop for small to medium sized municipalities in SA
Water Group Holdings (Pty) Ltd; Sarah Slabbert Associates
No. 2420

Project aims:

- To research and report best practice sustainable water and wastewater management in small- to medium-sized municipalities and produce a fourth WIN-SA lesson series comprising the following two case studies:
  - Case study 1: Wrapped up! - W_2RAP interventions that paid off
  - Case study 2: Risk-based planning delivers safe drinking water – a Blue Drop case study

- To establish the level of implementation (and impact thereof) of Risk Assessment Plans in municipalities that have completed W2RAP and WSPs

Estimated cost: R500 000
Expected term: 2014-2015

National survey of filamentous bacterial populations in activated sludge: identification and correlation with process parameters, wastewater treatment plant configuration, and geographical location

Cape Peninsula University of Technology; Durban University of Technology; City of Cape Town; ERWAT

No. 2471

Most municipalities in South Africa, including the City of Cape Town, treat AS reactors as 'black-boxes' and rely on chemical indicators of system health. Performance problems are thus usually addressed in a reactive rather than a proactive manner. Microscopic floc analysis and filament identification are simple, cost-effective procedures that can add value to the physicochemical tests currently performed at laboratories affiliated to WWTWs. Improvement in the performance of WWTPs will assist municipalities to achieve Green Drop status, in turn protecting the environment and minimizing human health risks associated with exposure to inadequately treated effluent. The filament populations in AS will be identified and correlated with WWTP location, and a large range of physicochemical parameters. These results will be used to validate an existing statistical model and will feed into the BIOS tool which is currently under development at DUT. This project will contribute by providing a tool to assist municipal engineers and process controllers to alleviate and/or prevent filamentous bulking and/or foaming in AS WWTPs.

Estimated cost: R1 600 000
Expected term: 2015-2018

In-line rheometry for continuous and efficient polymer dosing control to optimise sludge dewatering

Cape Peninsula University of Technology; City of Cape Town

No. 2472

Urbanization is putting enormous pressure on infrastructure including water treatment plants (WTP) and wastewater treatment plants (WWTP). Optimising existing plants is one way of prolonging the life span of such installations. Many WWT plants have sludge dewatering installations where treated wastewater sludge is dewatered for final disposal using land applications. The objective is to produce a filter cake with the highest total solids content and to achieve this the plant needs to be controlled optimally. One of the most expensive inputs in these plants is the polymers used as flocculants. Polymer is typically dosed at a rate of about 4 kg poly per dry ton solids, and at a polymer cost of about R50/kg, the annual chemical cost for a large wastewater treatment plant can total millions of rands. However, controlling the optimum dosing cannot currently be done in the process in real-time, although it has been shown that huge savings can be made by optimizing the dosing rates using rheology. In this regard, the Flow Process and Rheology Centre and their Swedish Partners at SIK, the Swedish Institute for Food and Biotechnology, Gothenburg, Sweden, have developed an Ultrasound Velocity Profiling

(UVP) system which, together with a pressure drop (PD) measurement, can continuously measure the rheological properties of viscous fluids in-line and in real-time. Out of this partnership, the Flow-Viz technology has already been tested at a WWTP in 2012 and 2014, and results have indicated that it's possible to measure the viscous properties of sludges. If this technology were successfully applied in controlling polymer dosing it could have a significant cost saving and improve the efficiency of sludge dewatering. This could also be extended to other process control aspects of other WWTP and WTP processes.

Estimated cost: R860 000
Expected term: 2015-2017

Endocrine disrupting compound removal by wastewater treatment plants

Tshwane University of Technology; University of Pretoria (Medical)

No. 2474

Worldwide reuse of surface water for potable water production is increasing and a significant share of this is from wastewater effluent. Being a water-scarce country, treated wastewater effluents have been playing a decisive role in refilling the demand of water in South Africa and approximately 14% of the potential water source is treated wastewater effluent. In this regard, increasing attention has been focused on endocrine disrupting compounds (EDCs) as pollutants in municipal wastewater. Studies have shown that these compounds can have a negative impact on the environment, and that in many cases they are not efficiently removed in wastewater treatment plants. Moreover, their destruction and transport out into the environment depend on the design and operational characteristics of these treatment systems and on the properties of the chemicals themselves. It is also important to note that insufficient measurements made at various stages within the wastewater treatment plants prevent adequate analyses on how each unit process contributes to degradation. Identifying the performance of each wastewater treatment process in removing EDCs will therefore assist in optimizing the existing treatment technology by developing accurate relationships between operational parameters and removal of these compounds. There is also a need to consider a mass balance approach that takes into account all forms of the compound in both liquid and solid phases. Little is known about the issues of potential concern in performing mass balances in the South Africa context. The project will mainly focus on three types of wastewater processes that include activated sludge processes, trickling filters and an oxidation pond system. A comparison study of these processes will reveal the most effective systems or/and the best performing stage in removing EDCs and how to optimise each stage, thereby addressing several key data gaps in the removal of EDCs in various WWTPs.

Estimated cost: R550 000
Expected term: 2015-2017

The contribution of WRC research to sustainable municipal wastewater and sanitation services

Sarah Slabbert Associates

No. 2476

At a workshop in March 2014, the Water Research Commission (WRC) and the International Water Management Institute (IWMI) grappled with the challenges

of how to enhance the uptake and impact of its research products (reports, articles, brief, guidelines, etc.). Making the findings of research projects available is unfortunately no guarantee that the target audience is aware of their existence, or that they will be taken up or used to sustain good wastewater and
sanitation services. On the one hand, a recent study's analysis of the WRC's statistics of online users of knowledge products over the past 5 years has found that municipalities do not feature among the top five user categories. On the other hand, the same study cited very positive examples of municipal officials' uptake of WRC research, which also implied impact: It therefore remains a challenge for the WRC to understand in more depth:

- What do municipal officials working in wastewater and sanitation services at different levels perceive to be their knowledge needs?
- What methods do they use to search for knowledge and how do they apply the knowledge that they have found?
- Are municipal officials aware of the WRC and its research products?
- Do any of the WRC research products cross the pathways of their knowledge needs, knowledge searches and knowledge use? If yes, which products, and how have they been used?
- Are there any success stories of uptake of WRC research that also illustrate a positive impact on sustainable wastewater and sanitation services?
- How can the WRC further contribute to better wastewater and sanitation services and assist municipalities to become more sustainable in this regard?

Estimated cost: R400 000
Expected term: 2015-2017

Programme 4: Wastewater sludge and faecal sludge management

Energy and resource recovery from wastewater sludge – a review of appropriate emerging and established technologies for the South African industry

TruSense Consulting Services; Stellenbosch University; ERWAT

No. 2475

Sludge management forms a huge part of wastewater operations. Whereas in the past sludge was viewed as nuisance waste to be disposed of at significant cost, there is now a general consensus in the wastewater industry that sludge is a potential source of valuable resources and alternative green energy. Moreover, sludge management and the shortage of electricity are also both known challenges in South Africa. Sustainable management of sludge and recovery of energy and other resources from sludge fall within the Water–Energy–Food Nexus programme. While there has been growing interest in implementing sludge-to-energy technologies, municipalities have lacked comprehensive information to enable them to make informed long-term decisions on which technologies to adopt. The current study therefore compares established technologies by evaluating biogas production in relation to other innovative emerging technologies resulting in a product that can be used either as solid biofuel or as soil conditioner, thereby contributing to the South African industry through provision of sustainable development solutions, new products and services for economic development, and human capital development. The project will therefore address the gaps in knowledge on sludge-to-energy technologies identified

in previous studies and also provide valuable information on both established and innovative emerging technologies that South African municipalities can use to formulate long-term sludge management strategies.

Estimated cost: R950 000
Expected term: 2015-2016

Characterizing municipal wastewater sludge for sustainable beneficial agricultural use

University of Pretoria; ERWAT

No. 2477

Project aims:

- To investigate the effect of sludge drying time and drying thickness on sludge: (a) nitrogen content, (b) organic matter composition, and (c) fertilizer value
- To investigate the effect of liquid sludge application based on crop water requirement vs. crop nitrogen requirement on crop growth and environmental pollution
- To investigate the nitrogen fertilizer value of composted sludge, belt-pressed and lime-treated sludge, aerobically-digested sludge and sludge from the Ladepa process in order to parameterize the database model

Estimated cost: R1 500 000
Expected term: 2015-2018

Guiding principles in the design and operation of a full-scale wastewater sludge digestion plant with enhanced CHP generation

Water Group Holdings (Pty) Ltd; City of Johannesburg; Johannesburg Water

No. 2478

The aim of the project is to provide a practical guide to water services authorities (WSA), water services providers (WSP), process managers and process designers who wish to implement integrated sludge treatment processes in compliance with the 2006 sludge guidelines. The guide will focus in particular on the associated risk of poor technology selection and non-beneficial use of funds. While compliance with the sludge guidelines is the main objective, the project will include value-added elements associated with a typical CHP plant, such as the improved generation of biogas, the enhancement of on-site electrical power generation and the control of struvite crystallisation after sludge digestion. While the project will not include any innovative processes, it will make critical linkages between the WRC Sludge Guidelines, appropriate technology, and well-integrated sludge treatment design and operation.

Estimated cost: R550 000
Expected term: 2015-2017

Programme 5: Sanitation technology and innovations

Eastern Cape school sanitation – pour flush pilot

Maluti GSM

No. 2444

The objective of this project is to install pour-flush sanitation facilities in two schools within the Chris Hani District Municipal area of the Eastern Cape.

Estimated cost: R372 100
Expected term: 2015

The development of wastewater anaerobic digestion for greater energy, water and nutrient recovery

University of Cape Town

No. 2473

This project is focused on the development of an intensified AD process in which water treatment is integrated through the nexus of energy-water-nutrient, producing biogas, purified water and high-value bioproducts from waste resources while recycling nutrients. Value can be created by intensifying the volumetric biogas production through decoupling COD depletion from methane production, allowing further downstream processes for clean water production as well as nutrient recovery (C, N, P) and bioproduct formation. The big-picture objective of this project is to utilise rural, industrial and municipal wastewaters which are currently treated with AD more fully, to integrate the process more successfully into actualising the energy-water-nutrients nexus. The project has potential to contribute towards the empowerment of communities, through managing waste to produce not only energy, as is the case currently, but also clean water and valuable bioproducts.

Estimated cost: R1 454 486
Expected term: 2015-2018

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 2: Integrated management

Revision of Natsurv 13: Water and Wastewater Management in the Textile Industry (Edition 2)

Cape Peninsula University of Technology; MKBros Development and Services

No. 2489

In 1993, the NATSURV 13 document stated that the annual water intake of the textile industry in SA was 30 x 106 m^3, with 70–80% of this intake later discharged as industrial effluents. In a country where water quality and availability issues are increasing, it is important to determine whether these figures are still accurate and determine how they have changed in the past two decades. Furthermore, wastewater management and wastewater treatment technologies have developed in strides in the past two decades, and it will be important to note if these management policies and technologies have been incorporated in the textile industry. The document will include a survey of the state and extent of the textile

industry in South Africa, and will contain 'best practice' knowledge which will ultimately have a positive impact on the environment and a potential impact on the economy if implemented by the industry.

Estimated cost: R900 000
Expected term: 2015-2017

Revision of Natsurv 10: Water and Wastewater Management in the Tannng and Leather Finishing Industry (Edition 2)

Chris Swartz Water Utilisation Engineers; Tannery Environmental Consultancy Services; International School of Tanning Technology; Cape Peninsula University of Technology

No. 2490

Tanneries produce wastewater streams that contain high pollutant loadings that have a very negative impact on the environment if not treated effectively and satisfactorily before discharge to public streams or municipal sewer systems. Ineffective treatment or process operation may also lead to serious odour problems from these industries, while some of the chemicals used in the tanning processes may be toxic to humans and to the environment. High salt loadings in the effluent streams from curing of hide also present considerable problems for municipalities and the environment. Any improvement in water management and minimisation of pollutant loads in the waste streams will be invaluable in addressing water demand management and pollution control in our water-scarce country. The product of this project, the NATSURV 10 document, will not only be a valuable tool for the various tanneries and leather-finishing industries in the country, but will also sensitise the industry as to how they can contribute holistically towards reducing water usage and, especially, effluent generation, and to improving the quality of the effluent streams that are discharged from the tanneries.

Estimated cost: R900 000
Expected term: 2015-2017

Revision of Natsurv 11: Water and Wastewater Management in the Sugar Industry (Edition 2)

Cape Peninsula University of Technology; MKBros Development and Services

No. 2504

The sugar industry in South Africa is mostly concentrated in KwaZulu-Natal. In 1985, sugar production was approximately 2 million tonnes per year (NATSURV 11, 1990). In 2008/09, the SA sugar industry was producing 2.3 million tonnes of sugar per year, about 40% of which was exported. South Africa is one of the world's leading producers of cost-competitive, high-quality sugar and this industry makes a significant contribution to the national economy. One of the aims of this project is to determine the current scope and extent of the sugar industry in South Africa, how the landscape of the industry has changed since 1990 and what projected changes lie ahead. The document will include a survey of the state and extent of the sugar industry in South Africa, and will contain 'best practice' knowledge which will ultimately have a positive impact on the environment and a potential impact on the economy if implemented by the industry.

Estimated cost: R900 000
Expected term: 2015-2017

Revision of Natsurv 9: Water and Wastewater Management in the Poultry Industry (Edition 2)

VitaOne8 (Pty) Ltd

No. 2505

The Natsurv reports for different industries have been well used since they were developed by the sector in the 1980s. However, South Africa and its industrial sectors have either grown or in some cases shrunk considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries, and therefore certain information contained in the national surveys needs to be updated. The project output will be a revised Natsurv 9 report which reviews and documents water and wastewater management processes in the poultry sector, with the goal of defining industrial best practices and identifying appropriate technologies for water and wastewater treatment.

Estimated cost: R900 000
Expected term: 2015-2017

Programme 3: Quantification, prediction and minimisation of water use and waste production

Revision of Natsurv 12: Water and Wastewater Management in the Pulp and Paper Industry (Edition 2)

Water Group Holdings (Pty) Ltd; Prodomos Technologies (Pty) Ltd

No. 2421

- Provide a detailed overview of the pulp and paper industry in South Africa, its changes since 1980 and its projected change(s). Representative samples of the respective industries will be used as case studies
- Critically evaluate and document the 'generic' industrial processes of pulp and paper industry in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critical evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name but a few.
- Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution.
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000
Expected term: 2015-2017

Revision of Natsurv 17: Water and Wastewater Management in the Steel Industry (Edition 1)

Water Group Holdings (Pty) Ltd; Prodomos Technologies (Pty) Ltd

No. 2422

- Provide a detailed overview of the steel industry in South Africa, its changes since 1980 and its projected change(s). Representative samples of the respective industries will be used as case studies.
- Critically evaluate and document the 'generic' industrial processes of pulp and paper industry in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critical evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name but a few.
- Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution.
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000
Expected term: 2015-2017

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

Shale water treatment

University of the Western Cape (SAIAMC); Wageningen University

No. 2502

While greatly increasing nations' wealth and creating thousands of new jobs, exploration of shale and unconventional natural gas production methods can have potentially serious negative environmental effects. One of the most serious public sector concerns in this regard is associated with groundwater contamination. It is of paramount importance for any commercial operator to have at hand effective water treatment technologies to alleviate the plethora of risks associated with the potentially disastrous contamination of the environment. Due to the unique geological situation in South Africa, locally produced shale water needs a tailored purification approach with the development of technology for selective removal of specific species. As the knowledge to be

created over the course of this project is focused on South African shale water, it is expected to be of great value to South Africa in particular. The project aim is to develop cost-effective water treatment systems tailored for the shale water market. New electrodes, absorbent integrated electrode manufacturing technology (with absorbents based on local minerals), and hybrid purification systems will be developed and demonstrated using a locally developed renewable energy system.

Estimated cost: R2 421 875
Expected term: 2015-2019

Fate and behaviour of nano-TiO_2 nanoparticles in simulated textile wastewater

University of Johannesburg; Cape Peninsula University of Technology; University of Johannesburg
No. 2503

The use of engineered nanomaterials (ENMs) to treat dyeing effluents creates secondary pollution in the form of metal oxide nanoparticles. Following increasing use and applications of nanotechnology, wastewater treatment plants (WWTPs) have been identified as a major point source for ENMs entering aquatic systems. Little is known about the removal efficiency and adverse effects of ENMs in WWTPs. For instance, ENMs in WWTPs may adversely impact on microbial consortia useful for the treatment process. Studies have been initiated only recently in determining potential removal mechanisms for ENMs during wastewater treatment as well as their fate and behaviour in terms of uptake and bioaccumulation. This project will investigate the fate and behaviour of doped and undoped TiO_2 and bimetallic oxide nanoparticles in a model wastewater treatment process. The study will establish the extent to which metallic- and metal-oxide nanoparticles are either removed or released during wastewater treatment, or persist in the treated water.

Estimated cost: R900 000
Expected term: 2015-2017

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 4: Mining in the 21st century

Paques pilot and demonstration plant

Project Assignments SA (Pty) Ltd; Paques bv
No. 2480

This project forms part of a programme focused 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 and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water in the Witwatersrand has identified the Paques process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South

Africa. This project will design, construct and operate a public Paques process pilot and demonstration plant, at a site in the Witwatersrand region.

Estimated cost: R2 800 000
Expected term: 2015-2018

Electro-coagulation pilot and demonstration plant

Tecroveer

No. 2481

This project forms part of a programme focused 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 and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water in the Witwatersrand has identified the electro-coagulation process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public electro-coagulation process pilot and demonstration plant, at a site in the Witwatersrand region.

Estimated cost: R2 800 000
Expected term: 2015-2018

Ettringite process pilot and demonstration plant

Miwatek

No. 2482

This project forms part of a programme focused 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 and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water on the Witwatersrand has identified the ettringite process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public Ettringite process pilot and demonstration plant, at a site in the Witwatersrand region.

Estimated cost: R2 800 000
Expected term: 2015

Alternative reverse osmosis pilot and demonstration plant

Miwatek

No. 2483

This project forms part of a programme focused 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 and treatment strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. The DWS investigation into the feasibility of various options for the long-term management of mine water on the Witwatersrand has identified the alternative reverse osmosis process as a treatment method which has potential for mitigation of the mine water situation in this region. However, the process has not been trialled at demonstration scale in South Africa. This project will design, construct and operate a public alternative reverse osmosis process pilot and demonstration plant, at a site in the Witwatersrand region.

Estimated cost: R2 800 000
Expected term: 2015-2016

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KSA 4: WATER UTILISATION IN AGRICULTURE

SCOPE

The strategic focus of KSA 4 is on increasing the system of knowledge for efficient use of water for production of food, forage, fibre, and fuel crops; improving food security, reducing poverty and increasing the wealth of people dependent on water-based agriculture; and ensuring sustainable water resource use. The requirements of present and future generations of subsistence, emergent and commercial farmers are addressed through creation and application of water-efficient production technologies, practices, models and information systems within the following five interrelated sub-sectors of agriculture:

- Irrigated agriculture
- Rain-fed agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

The challenge for applied research is contributing to finding sustainable solutions for water use in agriculture, with priority given to innovative new products which support economic development and inform decision-making for private business and public policies. In the process of undertaking these research projects, the composition of research teams endeavours to increase representivity of Black and female researchers; post-graduate students are trained to improve the expertise of human capital and encourage young scientists to choose a career in water research, while on-farm and participatory action research leads to empowerment of individuals and groups in rural communities.

This KSA strives to achieve a balance between 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 activities. Building on the baseline of completed projects, the priority themes approved for research commencing in 2015/16 were as follows: Determining the water footprint of selected fibre and fuel crops; water use of strategic biofuel crops; water use of agro-forestry systems for food, forage and/or fuel production; evaluation of the water use and nutritional productivity of food crops in the diet of the rural poor; contribution of inland freshwater fisheries to rural livelihoods; up-scaling of rainwater harvesting and conservation (RWH&C) to croplands and rangelands for food production and renewable fuel generation; modelling of irrigation farming profitability with curtailment of authorised water use; management guidelines for control of salinization with precision farming; seamless near-forecasting of rainfall for effective agricultural water management; and non-point source (NPS) pollution management from field to catchment scale.

OBJECTIVES

The strategic objectives of KSA 4 are as follows:

- To increase the biological, technical and economic efficiency and productivity of water use
- To reduce poverty through water-based agricultural activities

THRUSTS AND PROGRAMMES

THRUST 1: WATER UTILISATION FOR FOOD, FORAGE 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, RESTORATION 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.

COMPLETED PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD, FORAGE 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 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); University of Pretoria; CSIR

No. 1874

South Africa is following the international trend of liquid biofuel production, as noted in the South African Biofuels Industrial Strategy of 2007. This strategy highlighted the benefits of biofuel production in terms of alleviating poverty in rural areas, promoting rural economic development and stimulating agricultural production. A 2% blend of biofuels in the national liquid fuel supply, equivalent to an annual production of approximately 400 million litres of biofuel, was proposed by the former Department of Minerals and Energy (DME). To ensure sustainable biofuel production, South Africa plans to grow feedstock on currently under-utilised arable land and preferably under rainfed conditions. In 2006, the task team that developed the biofuels strategy urged the government to determine the impacts of biofuel feedstock production on both water quality and water quantity. The WRC responded to this request and funded a two-year (2007-2009) scoping study on the water use of biofuel feedstocks. The main aims of the scoping study were to (i) identify suitable feedstock for the production of biofuel, (ii) map areas climatically suited to feedstock cultivation, (iii) determine the available knowledge on feedstock water use, (iv) model the water requirements of selected feedstock, and (v) identify existing knowledge gaps. The scoping study report concluded that both sugarcane and sweet sorghum show potential to use more water than the natural vegetation they may replace, whilst other crops (e.g. sugarbeet, canola, soybean and sunflower) do not. However, the scoping study highlighted that for the emerging feedstocks (e.g. sugarbeet and sweet sorghum), parameter values were gleaned from the international literature. The literature also provided conflicting water use figures for certain feedstocks (in particular sweet sorghum) and it was found that knowledge is surprisingly limited for certain crops (e.g. canola). The scoping study recommended a need to better understand the water use and yield of biofuel feedstocks. In addition, a more detailed mapping approach was required to identify

feedstock growth areas that considered additional site factors (not just rainfall and temperature). Based on these recommendations, the WRC initiated and funded a six-year (i.e. more comprehensive) follow-up study. This six-year solicited project began in April 2009 and was led by several partners. The aims of the follow-up study were broadly similar to those of the scoping study, except for the need to estimate crop yield and bio-fuel yield.

Cost: R7 400 000 (incl. leverage)
Term: 2009-2015

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

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 (Microbiology and Plant Pathology); University of KwaZulu-Natal (Howard College)
No. 1875

The general aim of this project was to investigate the links between water quality and microbial food safety of fresh minimally processed and frozen vegetables and fruit.

Microbial analysis of irrigation water showed that the *E. coli* levels in the irrigation water (5 rivers, 10 dams) at the 14 sites tested exceeded the DWAF (1996) guidelines of ≤ 1–1 000 CFU/100 mL for crops to be eaten raw. Irrigation canal water used at two of the sites tested complied with the DWAF (1996) guidelines for crops to be eaten raw. However, although the *E. coli* counts of the primary irrigation source (rivers, dams) were unacceptably high, a reduction in numbers was observed for dam water and a further reduction was observed for the water from the micro-irrigation pipes, drip-irrigation and overhead irrigation pivots. Salmonella was isolated from up to 22% of the water samples from a selected site. No *Escherichia coli* O157:H7 and *Listeria* monocytogenes were isolated from any of the irrigation water samples from the sites tested. The current national guideline for fresh produce provides guidance values only for the ready-to-eat stage of the chain. The microbial levels on crop surfaces were generally higher in the field compared to the product at the end of the supply chain. *E. coli* and diarrhoeagenic *E. coli*, as well as viruses (NoV GI, NoV GII, and HAV), were isolated from fresh produce at certain stages along the supply chain, but not from the beginning to the end of the chain. The fresh produce with the highest microbial contamination was leafy vegetables (lettuce and spinach). Generally the percentage of pathogens present on

vegetable products was higher when compared to fruit samples. This is an important finding since it confirms the previous reports that fruit in general is by its very nature and production system a lower risk product than vegetables. This is mainly due to production practices where the crop is grown in closer proximity to the ground and the potential to be in direct contact with irrigation water for extended periods of time is thus greater.

Cost: R6 219 200 (incl. leverage)
Term: 2009-2015

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water use and economic value of the biomass of indigenous trees under natural and plantation conditions

CSIR (Natural Resources and the Environment); Forestlore Consulting; Peter Dye Consulting; University of KwaZulu-Natal (Pietermaritzburg)

No. 1876

The general aim of this project was to measure and model the water use and growth of indigenous trees in different types of tree systems, and to quantify the economic benefits and costs of the biomass production under a range of bio-climatic conditions in South Africa. This aim was addressed by initially organising a stakeholder workshop and subsequent short-listing and selection of priority indigenous tree species and forest types for measurement in the project. Detailed measurements were thereafter taken of tree/forest water-use, above-ground stem biomass increments, weather variables, soil water fluctuations and tree/forest attributes. The data facilitated the calculation of water use efficiency (WUE) for the respective indigenous tree species and forest types, as well as an understanding of the driving variables (weather, water availability, tree/forest attributes). Parameterisation and testing of the MAESPA and Penman-Monteith ('Big-Leaf'-type) models at a selection of these sites, investigated their ability to replicate the field observations of tree and forest water-use. Economic and financial assessments were conducted on informal indigenous tree product markets, as well as more formal/recognised indigenous wood markets. Information on potential products, supply and demand processes, trading and values associated with those markets was documented. Consideration was finally given to the necessary data and information required to assess WUE and site-species optimality, taking into account the economic/financial value of preferred indigenous tree species. Based on experience gained from field measurements it took into account practicalities associated with obtaining the requisite data, compared to a modelling approach.

Cost: R6 799 100 (incl. leverage)
Term: 2009-2015

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

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); University of Limpopo

No. 2082

Lack of water and land use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient physical, economic and social 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. Findings from this research project will contribute to bridging the divide between the abovementioned current reality and government policy intentions. This will deepen the understanding of social dynamics at the community and household level that impact on the empowerment of women and attainment of sustainable food production, including better understanding of institutional and organizational impediments affecting the decision-making powers of women. Better understanding of the impact land reform and rural development policies have on women is of specific importance. Furthermore, this research will improve the understanding of co-operative governance and inter-governmental relations at national, provincial and local level, regarding interaction with affected people in rural areas and the related household food security. In particular, the socially-embedded practices in traditional areas which are affecting the security of women with reference to household food production and improving livelihoods require attention. The three irrigation schemes studied are situated in Steelpoortdrift (Sekhukhune District); Mashushu (Capricon District) and Rambuda (Vhembe District). The main objectives of the project were to get a comprehensive understanding of constraints, challenges, opportunities and interventions required for empowerment of women to promote household food security and rural livelihoods through increased water productivity and land access as they relate to crop cultivation.

Cost: R3 000 000
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; University of Fort Hare; Rhodes University

No. 2083

High levels of poverty and deep inequality remain major challenges in post-apartheid South Africa and Blacks living in the rural areas of the country are the most severely affected by these. In 2011, it was estimated that 23 million people (45.5% of the population) were living in poverty, 26% were food insecure, and 13.4% suffered from persistent hunger. Poverty was closely associated with lack of education and was higher for both women and youth. The Eastern Cape was ranked as the second-poorest province in the country, with 69.5% of residents assessed as poor, and an unemployment rate of more than 40%, which is far higher than the national figure of 25%. Social grants provided the main source of income for 37.9% of the households. In rural areas, where opportunities for wage labour employment are low, rain-fed agriculture is the third most important means of livelihood, after remittances and wage labour from low-skilled jobs, though only contributes some 10% to household survival. It is well-established that a poorly-functioning rural economy with undeveloped infrastructure, weak market linkages and poor agricultural support services isolates rural households from the mainstream economy and from critically important agricultural value-chains. Weak and conflicted land institutions add uncertainty and also limit transactional opportunities. Despite these systemic challenges, current national development, agricultural, and water policies and strategies focus on the need for a stronger, more vibrant smallholder agriculture sector with ambitious goals for intensive crop production activity.

Cost: R3 000 000
Term: 2011-2015

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); Stellenbosch University

No. 1880

In this project various data sources and methodologies for the identification of areas prone to salt accumulation and waterlogging were investigated. This included land cover mapping, bare soil analysis (i.e. direct approach), multi-temporal crop condition monitoring (i.e. indirect approach), terrain analysis, within-field anomaly detection, and decision tree analysis. The occurrence of salt accumulation and waterlogging in generally small patches in South African irrigation schemes poses unique challenges and will require a robust modelling strategy. It is important to note that no model based on remotely-sensed data will ever replace in-field monitoring. The purpose of this study was to develop a method to detect

potential areas of salt accumulation or waterlogging so that in-field monitoring can be performed. Various factors have to be considered when selecting a specific source of satellite imagery for a classification project. The spatial, spectral and temporal resolutions are important factors, as is cost. Despite the efforts of scientific research, there is currently no robust model for accurately and consistently extracting soil water content or soil salinity from synthetic aperture radar (SAR) imagery. This science is very much still in an experimental phase, and most authors agree that great strides still need to be made before such an application can be operational. The direct and indirect remote-sensing approaches show the most promise as they can be applied to high resolution, multispectral satellite imagery. Statistical methods such as regression, partial least squares regression and multi-regression have been shown to be successful in a number of studies and should be investigated further. Surprisingly little attention has been given to the use of modern image classification and machine learning algorithms (e.g. classification and regression trees, decision trees, support vector machines and random forest) for mapping waterlogged and salt-affected areas. Such applications will likely be very effective given their success in other remote-sensing applications (e.g. land cover mapping). From the review of the literature it is clear that there is a large body of work that is focused on finding practical solutions for monitoring waterlogging and salt accumulation. None of the methods stood out as being the ultimate solution, with each having some kind of limitation for operational application. It is consequently likely that the solution lies not in one technique but in a combination of methods. However, to find the best combination of methods for monitoring waterlogging and salt accumulation, each of the most promising techniques must be evaluated in a South African context to better understand their individual strengths and limitations. The within-field anomaly detection (WFAD) method was used to quantify the extent of affected irrigation areas. On average, 3.3% of the area on 9 irrigation schemes considered was found to be affected by waterlogging and salt accumulation. This estimate was adjusted to 6.27% by adding abandoned fields. Applying this figure to the 1.5 million ha under irrigation in South Africa, the area that is salt-affected and waterlogged is 94 050 ha.

Cost: R3 693 800
Term: 2009-2015

Development of technical and financial norms and standards for drainage of irrigated lands

ARC (Institute for Agricultural Engineering); University of the Free State; University of KwaZulu-Natal (Pietermaritzburg); Bioresources Consulting; OABS (Pty) Ltd

No. 2026

There are numerous benefits, both economic and environmental, of well designed and constructed surface and sub-surface drainage systems in irrigated agricultural lands. The need arose in South Africa to research the technical and financial aspects of drainage systems to ensure that current practices were technically sound as well as being financially feasible. As a result of thorough research three comprehensive volumes were produced. The manual provides a comprehensive text on the subject of both the technical and financial aspects of surface and sub- surface drainage and will benefit the following persons in both the engineering and financial sectors:

- Engineering technicians in the country's provincial agricultural departments
- Financial and technical advisors at co-operatives and agri-businesses who offer financial and technical advice to farmers
- Banks who offer financial assistance to farmers
- Technical personnel at engineering consultancies
- Students in the field of agricultural or bio-resources engineering

In addition examples are presented in the text which illustrate application of the underlying scientific and economic principles which are unique to the field of drainage.

Cost: R4 000 000
Term: 2010-2015

Programme 2: Impact assessment and environmental management of agricultural production

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 (Grassland Science); CSIR; AGAMA Biogas; Rhodes University

No. 1955

In South Africa, one of the factors responsible for low agricultural production is unreliable rainfall and poor water resources. In recent years the WRC has funded a number of studies on rainwater harvesting to improve water resources. Different rainwater harvesting techniques have potential application in communal rangelands. One such application is the use of rainwater for energy provision in the form of biogas. The SA domestic biogas feasibility study has shown that, in addition to rainwater, organic matter (e.g. manure) is required to implement biogas technology in rural households. While manure of any kind can be digested to produce biogas, with varying amounts of biogas per kilogram of feedstock, the focus here is on cattle manure because of the strong tradition of ownership of cattle in rural communities, as well as the cultural relationship between cattle ownership and status/wealth in a given community. The amount of manure required and factors affecting its availability and accessibility for biogas production formed part of this project. In terms of natural resources, rangeland remains the main and the cheapest source of fodder for South Africa's animal production. However, in many communal areas of South Africa, rangelands are in poor condition which has a negative effect on animal production. Communal range improvements will directly benefit livestock and numerous other users since rangelands are multifunctional, providing many non-forage goods and services in addition to forage. This research project focused on whether rural households can produce biogas from kraal manure effectively and efficiently, and whether biogas can replace other sources of energy such as fuel wood and paraffin that are more costly and hazardous to human health and the environment. The integrated management system comprises a biodigester (closed storage or tank in which biogas is generated), harvesting of rainwater, kraaled cattle, and the production of food and fodder. The

biodigester will produce biogas by anaerobically digesting the combined harvested water and cattle manure. The liquid bioslurry effluent will be used to water and fertilize the food and fodder crops.

Cost: R5 000 000
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); University of Pretoria; North-West University (Potchefstroom)
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, either through crop spraying or animal disease control, may enter and pollute rivers and dams and cause endocrine disrupting effects in animals and humans that use the water. A scoping study was done in 2008 which indicates that there was no clarity on the extent and level of contamination of water resources by agricultural products with endocrine disrupting properties. It was noted that a number of WRC studies have been done, identifying different chemicals in different areas that are hazardous as well as having endocrine disrupting properties. Some studies identified EDCs in water resources and indicated endocrine disrupting effects in sentinel species in and around contaminated water resources. It was noted that 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. Though pesticide monitoring studies are limited in South Africa, there is sufficient information to indicate that many pesticides that are in current use enter surface and ground water. This is particularly relevant considering the fact that many communities do not have reliable or even any access to treated water and often make use of water collected directly from the resource for drinking purposes. Given the potential human health effects associated with exposure to agro-chemicals and their intensity of use, in combination with the questionable supply and quality of drinking water in many South African communities, it is important to identify and prioritize: (i) pesticides that are particularly toxic, (ii) areas where people may be exposed to these priority chemicals. Furthermore it is important to identify sources of priority compounds used in South Africa that could potentially result in exposure and associated negative effects on human and animal health. Intensive use of pesticides increases the potential for exposure to occur. The objective of this project was to determine the extent and level of contamination by agricultural chemicals such as pesticides, herbicides and plant growth regulators, and including endocrine disruptive (ED) properties and selected risk assessments for the environment (animal and human health).

Cost: R4 109 825 (Incl. leverage)
Term: 2010-2015

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

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: 2011-2016

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 (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: (i) determine water use and irrigation requirements of most common farmers' practices including kikuyu/ryegrass, legume/ryegrass mixtures and lucerne; (ii) evaluate irrigation systems (flood, sprinkler and sub-surface drip) for lucerne production; (iii) conduct detailed physiological studies of lucerne as affected by different water stress treatments, and (iv) 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

Water footprint of selected vegetable and fruit crops produced in South Africa

University of Pretoria (Plant Production and Soil Science)
No. 2273

The vegetable and fruit industries are highly dependent on the availability of irrigation water and are clearly responsible for significant freshwater consumption. Numerous studies have evaluated irrigation practices

and water use by horticultural crops in the country. Information is lacking on the long-term production and water consumption patterns at regional and industry scales over the entire agri-food production chain from field to fork. Standard methodology to calculate water footprints was recently published by Hoekstra et al. (2011). According to this methodology, water footprint assessments consider both the direct and indirect water consumption and pollution of a consumer or of a product. Blue-, green- and grey-water footprints make up the total water footprint, and temporal and geographic components are included. Blue water refers to surface and groundwater available to multiple users, green water is water originating from rainfall that is stored in the soil and available for vegetation growth only, and grey water refers to the volume of water required to dilute emitted pollutants to ambient levels. Generally, blue water is scarcer and has higher opportunity costs, meaning that irrigated crops with lower ratios of blue to green water consumption are viewed more favourably. Detailed water footprint assessments using standardized, state-of-the-art methodology for important vegetable and fruit crops is essential to: (i) enable regional-scale integrated water resource management and drive policy formulation, (ii) better understand the water-related risks to the production of vegetables and fruit in the country, and (iii) facilitate the identification of opportunities for reducing water use within the production chain to ensure the sustainability of these industries.

Estimated cost: R2 750 000
Expected term: 2013-2017

Determining water use of indigenous grain and legume food crops

University of KwaZulu-Natal (Crop Science)
No. 2274

Completed and ongoing WRC-funded research work (Projects K5/1579//4 and K5/1771//4) to determine water use has mainly focused on African indigenous vegetable crops. There is, however, recent evidence of knowledge gaps on water use, agronomic practices, etc., of indigenous legume and grain crops. The indigenous grain and legume crops include grain sorghum, maize landraces, cowpeas and Bambara groundnuts. Furthermore, limited research results on water use are available and little crop water use modelling has been done on these crops. There is clearly a need for research-based knowledge on water use which will contribute to higher production, water use productivity and food security. More research is required on these neglected crops to better inform farmers and extension officers of appropriate management practices. Quantifying water use should therefore be done for combinations of indigenous crops (such as grain sorghum, maize landraces, cowpeas and Bambara groundnuts) by means of intercropping or crop rotations in comparison with intercropping or crop rotations of conventional crops (such as hybrid maize, dry beans, green peas and groundnuts). This will make it possible to broaden the crops and products in the food basket for consumption in a more balanced diet of starch and protein for rural household members. In addition, this knowledge of water use will provide opportunities to prepare for the challenge of climate change by adapting agronomic practices and cropping systems, thereby preventing detrimental livelihood impacts.

Higher production and supply of indigenous grain and legume food crops will enable storage and inter-seasonal transfers, to specifically bridge the gap in nutrition during late winter and early spring. From a perspective of rural development there is also the potential of processing and value-adding in the food value chain of these crops. As a whole it is therefore imperative to better understand the water use of indigenous grain and legume crops in the context of intercropping, to improve the fertility of the soil, and of producing food crops which combine staple grains with legumes as protein sources.

Estimated cost: R2 750 000
Expected term: 2013-2017

Quantifying citrus water use and water stress at tree and orchard scale

Citrus Research International
No. 2275

Citrus is the largest exporter in terms of volume and one of the largest in terms of the earning of foreign exchange, with more than 100 million 15 kg cartons exported annually. The 58 000 hectare citrus industry provides more than 100 000 jobs that support more than 600 000 people, but the whole industry is dependent on irrigation. Citrus is a perennial crop which requires a constant supply of water in order not to limit yields and returns on investment. Due to climate change, established production areas are likely to become drier, which will place increasing pressure on water resources and irrigation management to maintain productivity.

An ongoing WRC research project (K5/1770//4) is using a sap-flow technique to quantify water use of mature citrus, deciduous fruit and nut tree cultivars under best management practices. Initial findings indicate results that are contrary to expectations, specifically for citrus. In addition an external international review recommended more in-depth research to first validate measuring techniques; and secondly to quantify water use for different growth stages for different cultivars. The more detailed research must investigate water use over seasonal growth stages, from planting to mature canopy size, and water stress in relation to fruit yield and quality. In order to provide effective advice to both established and emerging commercial farmers on irrigation methods and scheduling, accurate knowledge is required on water use. The emerging commercial farmers, who comprise approximately 300 of the 2 700 citrus growers and who are supported by the industry through bursaries, mentoring and extension, are especially in need of this information. All citrus fruit producers are faced with a major challenge in maintaining high yields per hectare and fruit quality whilst simultaneously achieving viable returns and ensuring sustainability. Given the increase in competition for water between irrigation agriculture, secondary industry and domestic water use, more knowledge is required on citrus water use for growers to remain competitive and justify future production.

Estimated cost: R2 750 000
Expected term: 2013-2017

Determining the water footprints of selected field and forage crops towards the sustainable use of fresh water

University of the Free State (Agricultural Economics)

No. 2397

Significant amounts of water are used in the agricultural sector to produce food, forage and fibre to meet the ever-increasing world-wide demands. According to the Department of Water and Sanitation, 60% of fresh surface water is used by irrigated agriculture, making it the largest single user of water in South Africa. While being the largest user of fresh water, irrigated agriculture is also expected to contribute significantly towards poverty alleviation in South Africa through job creation and increased economic activity in rural areas. The allocation of fresh water to irrigated agriculture thus holds substantial social and economic benefits for South Africa. The establishment of standardised procedures for calculating blue and green water footprints for irrigated field and forage crops in South Africa will contribute towards the setting of accurate benchmarks for fresh water use along the life cycle of the crops. By linking the water footprint applications to economic and social analytical tools, the social and economic impact of proposed changes in water use behaviour will be understood. The analysis of consumer awareness, preference and willingness to pay for water footprint information on product labels will give insight into the scope for incentivising water users through price premiums to use fresh water efficiently. This project will report on standardised procedures for calculating green and blue water footprints of irrigated field and forage crops, which will ensure that water footprints can be compared and will allow for benchmarks to be derived for water use along the life cycle of the crops.

Estimated cost: R3 000 000
Expected term: 2014-2019

Quantifying water use of high-performing commercial apple orchards in the winter rainfall area of South Africa

CSIR (Natural Resources and Environment)

No. 2398

Within the deciduous tree fruit industry, pome fruit (apples and pears) is the biggest fruit group in terms of area, volume, contribution to GDP and earning of foreign exchange. South Africa is the 7th biggest exporter of apples in the world and the main Southern Hemisphere competitor is Chile, which is third in terms of export. South Africa is also the 6th biggest exporter of fresh pears, with Argentina the biggest fresh pear exporter in the world and the main Southern Hemisphere competitor. The deciduous fruit industry (including table grapes) employs 106 000 people with 424 000 dependents. Employment in apple farming consists of 27 800 labourers with 111 200 dependents. Currently there is limited knowledge of water use of young apple orchards up to full-bearing age in South Africa. The focus of water use research should be on Golden Delicious and Cripps' Pink cultivars on M793 rootstock, which is the industry standard. Golden Delicious is the major mid-season cultivar, with 24% of the area planted. Cripps' Pink

is a late season highest value cultivar, with 9% of the area planted and experiencing growth potential. Within the winter rainfall area, 28% of apples are produced in the Ceres region, primarily in the Koue Bokkeveld climatic zone, and 42% in the Elgin/Grabouw/Vyeboom/Villiersdorp region and climatic zone. Within these regions soils vary considerably and will influence site selections. Soils should therefore be selected to effectively quantify the water balance of the orchard and for comparison between climatic zones. Based on results of completed research it is clear that there is still an existing knowledge gap on water use of apple orchards as well as water use efficiency under local conditions. Increase in efficiency of water use will enable expansion of the area under apple production, or alternatively allow water savings that can be transferred to other sectors or improve the resilience to drought. Research is therefore required to quantify the water use and model water use for future extrapolation for different apple cultivars to wider production regions. This research project should provide a baseline for expansion of this type of research to other deciduous fruit types. The research output will inform strategic decisions by the deciduous fruit industry and relevant government departments.

Estimated cost: R3 000 000
Expected term: 2014-2018

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

Stellenbosch University (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 (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

Knowledge transfer on water quality management for improved integrated aquaculture and agriculture systems

Stellenbosch University (Aquaculture)
No. 2276

South Africa has a large number of irrigation dams and networks that can potentially be used for integrated aquaculture–agriculture practices. Many of these water resources have not realised their potential. The challenge remains how Government can provide support to develop the aquaculture sector, particularly in rural and peri-urban areas. The perception is that farmers are not effectively

engaged or strategically supported. Research-based knowledge is available on water quality management in farm irrigation dams and extension manuals have been developed. However, it is not fully understood how much of the knowledge is sufficiently interpreted and successfully applied. Access to technology is one of the major constraints for small businesses development in South Africa. It is further elaborated that much of the available knowledge does not reach household and producer level. In order to determine the development agenda, technology transfer from the source to the receiver needs attention. Technology transfer was most successful when conducted at a time when people had a specific need for it in their projects. During this process, engagement with the farmers is a crucial element for success. To achieve successful technology transfer, the following elements must be understood:

- What information is available to aquaculture and agriculture and how it is disseminated
- What media/modes are used by the farmers to access information
- In what ways is accessed information utilised
- What are the constraints to information routes at farmer/producer level
- What thinking/rational processes drive information prioritising
- How much of successful farming practice is based on existing and new knowledge
- What are the cost implications of information dissemination

Estimated cost: R1 950 000
Expected term: 2013-2017

Revision of the 1996 South African Water Quality Guidelines: Development of risk-based approach using irrigation water use as a case study

University of Pretoria (Plant Production and Soil Science)
No. 2399

The SA water quality guidelines of 1996 comprise one of the most widely-used tools in water quality management. However, they are now significantly out of date. A Phase 1 Department of Water Affairs (now Department of Water and Sanitation – DWS) project was completed in 2008 that performed a needs assessment, developed a general philosophy and described the general specifications of a decision support system (DSS) for revised water quality guidelines for South Africa. An initiative within DWS is under way to secure approval and funding for Phase 2 to revise these guidelines. The new guidelines will be different in a number of fundamental ways. Firstly, they will be risk-based – a fundamental change in philosophy from the 1996 guidelines. Secondly, they will allow for much greater site-specificity – a widely-recognised limitation of the generic 1996 guidelines. Thirdly, they will be made available primarily in a software-based decision support system. The overall DWS initiative aims to develop a DSS for all significant water users. With this project a start is made to revise the guidelines for irrigation water use.

Estimated cost: R2 000 000
Expected term: 2014-2016

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

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

Rehabilitation of grasslands after eradication of alien invasive trees

Rhodes University (Institute for Water Research)

No. 2400

Invasive alien plants (IAPs) remain a serious threat to the water supply and to storage reservoirs throughout South Africa. IAPs are known to use a large quantity of water through evapotranspiration (ET), and the clearing and control of IAPs has been a major activity of the Working for Water (WfW) programme. Water saving has been the primary motivation for the programme. Successful clearing of these often aggressive woody trees and shrubs requires careful regeneration of effective indigenous vegetation cover after the physical clear-felling and removal of the IAPs. Application of effective post-clearing

management regimes is required in order to improve the grass cover within catchments and this can ensure that there is controlled run-off and groundwater recharge. The research project will address issues in the following areas:

- Sustainable development solutions: applicability of Payment for Ecosystem Services (PES) to sustainable management of grasslands and IAPs on land under communal tenure; improved models that provide better estimates for ET, water use productivity (WUP) and livestock water productivity (LWP)
- Empowerment of communities: sustainable management by rural communities where livestock farming plays a crucial role in livelihood strategies; optimizing the land-use options available to graziers using WUE and LWP concepts
- Informing policy and decision making: providing evidence-based scientific input into the policies of WfW, DWS and the DAFF
- Human capital development in the water sector with training for post-graduate students in ET modelling and hydrology. Improved models for ET estimations in South Africa using earth observation will be a significant contribution to further understanding of the impact of changes in land-use on water supply and encourage sustainable land-use practices.

Estimated cost: R4 300 000
Expected term: 2014-2019

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Empowerment of women 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 (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

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 (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: R3 070 465 (incl. leverage)
Expected term: 2012-2016

Action-oriented development of a strategy for knowledge dissemination and training for skills development of water use in homestead gardening and rainwater harvesting for cropland food production

Rhodes University (Environmental Learning Research Centre)

No. 2277

Household food security in South Africa remains a national challenge with an estimated 59% of 13.7 million households being food insecure, with hunger and chronic malnutrition being widespread within this group. Yet, present utilisation of available land and water resources for smallholders (0.5-10 ha), both in home-gardens and fields remain low. As it is women who are responsible in the majority of cases for farming decisions, they are a key group to target in initiatives aiming for increased crop-production and food-security. There is a substantial body of training information in the public domain which responds to the multi-faceted crop-production challenges faced by small growers. Two recent WRC research products are prioritised; one targeting homestead food production and the second water-harvesting and conservation techniques. In addition, there are other potentially useful publications for use in knowledge mediation processes. These include, for example, WRC grey-water re-use guidelines and in-field rainwater harvesting manuals. The challenge of achieving impact from research outputs is a global one; and is related to what is now recognised as inadequate Research-Develop-Disseminate-Adopt (RDDA) assumptions of how knowledge is/ought to be mediated in society. Contemporary theories of learning and change indicate that for knowledge or information to become meaningful, there is a need for the information to be related to the situation and experience of the user; and also to provide new knowledge or information that can expand existing knowledge and/or practice. The choice of strategic approach to achieve effective knowledge dissemination and uptake to transform available knowledge into productive practices will be determined by those opportunities that unfold during the project, including consultations with both learning organisations and mass-media organisations (TV, radio etc.), and feedback with homestead gardeners and smallholder farmers.

Estimated cost: R1 950 000
Expected term: 2013-2017

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 (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

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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 KwaZulu-Natal and North West Provinces

University of KwaZulu-Natal (Agriculture Sciences and Agribusiness); African Centre for Food Security

No. 2278

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 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 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 negotiating higher prices and improve operating margins. For this purpose ways must be found to enable more productive farming practices,

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: 2013-2017

The optimisation of electricity and water use for sustainable management of irrigation farming systems

University of the Free State (Agricultural Economics)
No. 2279

Electricity tariff structures have changed over the years, while electricity rates have recently escalated considerably and are expected to continue increasing in future. This requires a change in design norms and standards as well as a shift in emphasis to life-cycle cost evaluation. This subject was last formally researched more than 10 years ago, with publication of a report in 2002 (WRC Report No 894/1-4/02), followed by technology transfer activities (WRC Report No 274/05). This research output clearly needs to be revised and guidelines must be updated. Over the intervening years, new technologies have become available, such as variable speed drive (VSD) and energy-efficient motors (with a new classification system). Better engineering practices for pumps, including auto-restart and remote control, have led to increased accuracy and energy efficiency. It is therefore essential to evaluate and compare different technologies on the basis of efficient energy/power use and operating cost over the life cycle of the irrigation system. In addition, better automatic weather stations are accessible and convenient irrigation scheduling techniques, such as continuous logging probes with telemetry, can be applied. This enables more efficient use of water, reduced electricity consumption and higher food production. At the same time there are pressures to reduce the carbon and water footprint, especially for export food markets. In so doing, costs must be lowered, profitability and competitiveness increased and water use productivity improved. However, farmers need advice and extension based on user-friendly guidelines, in order to respond to these pressures and incentives by changing irrigation practices. These practices that influence electricity power use include determining water use of crops, soil water monitoring, application rates of water, pumping water from the river or storage dam to the field, installing energy-efficient motors, selecting correct pipe sizes, and regular maintenance of equipment, etc. Measurement and verification therefore requires determining the baseline and implementing an information system for management of reduced energy/electricity consumption and optimisation of water use on irrigation farms.

Estimated cost: R1 950 000
Expected term: 2013-2017

Wide-scale modelling of water use and water availability with earth observation/ satellite imagery

Stellenbosch University (Environmental and Geographical Studies)

No. 2401

It is clear that both the land area and water resources available for irrigated crop production is very limited in South Africa. With the added pressures of climate change, population growth and the impact of a decline in water quality, the need for improved assessments of the current water resource uses and land uses is critical. Actions related to improved water use productivity and irrigation expansion or water reallocation can only follow once this information is available. Use of remote-sensing data, together with algorithms developed over the past 20 years to estimate actual evapotranspiration (ET), is an internationally accepted alternative and improves the traditional methods used to estimate or measure actual ET. Remote sensing data is routinely and frequently captured across the world. It is frequently used in deriving land cover–land use maps and hence suitable for estimating the area under irrigated agriculture. Remote-sensing data utilised in energy balance modelling has the potential to provide recent estimates of ET. Combining these remote-sensing based datasets will provide estimates of crop ET and total amount of water utilised by irrigated agriculture. Using remotely-sensed data within a framework for water accounting will be invaluable for water resources planning. A water accounting framework can provide an overview on water resources (per selected area) and facilitate decision making. The consumptive use by various land uses need to be understood prior to new water allocations. Various international initiatives have been developing water accounting systems to support water managers and decision makers. The usefulness of such a framework will be tested and illustrated in this project.

Estimated cost: R5 010 940 (incl. leverage)
Expected term: 2014-2018

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

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

Vulnerability, adaptation to and coping with drought: The case of the commercial and subsistence extensive livestock sector in the Eastern Cape

University of the Free State (DiMTEC)

No. 2280

Dry periods and droughts remain the major meteorological factor with devastating impacts on the livelihoods of most rural people in South Africa. The agricultural sector specifically incurs millions of Rands in losses every year. For example, the direct mean annual loss (MAL) to the extensive livestock sector in the Northern Cape alone is in the excess of R350 million. Little evidence is available of the required adaptations to reduce vulnerability and increase resilience of farming enterprises to natural hazards such as drought. Given the expected increase in these extreme events due to climate change, more research is essential on how vulnerability can be reduced in order to prevent future disasters. The proactive approach towards drought risk management emphasizes the need for coordination and collaboration among all role players. This includes coordination between monitoring agencies in terms of reliable early warning systems, communicated in a comprehensible way to decision-makers, farmers, agricultural businesses and all that have an interest in agriculture. Collaboration at national and provincial level between the Department of Agriculture, Forestry and Fisheries (DAFF) at national level, provincial Departments of Agriculture, National and Provincial Disaster Management Centres (NDMC and PDMC), Department of Water Affairs (DWA), South African Weather Service (SAWS) and others is essential in this regard.

Estimated cost: R2 950 000 (incl. leverage)
Expected term: 2013-2017

Assessing the impact of erosion and sediment yield from different land uses in farming and forestry systems and their effect on water resources in selected catchments of South Africa

University of KwaZulu-Natal (Centre for Water Resources Research)

No. 2402

Recent soil erosion mapping and modelling studies conducted by DAFF and the ARC-ISCW indicate that large parts of South Africa consist of highly erodible soils with widespread soil erosion evident. Soil erosion not only involves the loss of fertile topsoil, reduction of soil productivity and reduction in crop yield over time, but also causes water management problems, especially in semi-arid regions such as South Africa where water scarcity is frequently experienced. It must be noted that soil erosion cannot be prevented but must be limited. Siltation of storage dams is acknowledged to be a major problem in South Africa and better understanding of erosion and sediment yield is important to limit the cause of siltation. Phosphates are also linked to sediments contributing to eutrophication of dams and estuaries. Sediments in water furthermore increase the wear and tear of nozzles and hydraulic pumps for irrigation. It has also been highlighted in completed studies that better knowledge of limiting erosion will contribute to changing the behaviour of farmers by adopting conservation farming practices. Incorrect land use practices including overgrazing of natural grasslands is one of the major contributing factors to erosion and sediment yield. Completed WRC-funded research recommended that further investigation should focus on the connectivity of sediment delivery pathways and develop precautionary measures to limit the direct discharge of sediment into streams. Attention in this project will be given to quantification of sediment detention, retention or reaction to specific controls in stream networks, including farm dams, wetlands and buffer strips.

Estimated cost: R2 200 000
Expected term: 2014-2018

The modelling of rainy season characteristics and drought in relation to crop production in the Levubu catchment of the Limpopo Province: Climatology and climate change perspective

ARC (Institute for Soil, Climate and Water)

No. 2403

Drought is one of the most disastrous climate-related hazards in the world, which has significant impact on agriculture, environment, infrastructure and socio-economic activities. In semi-arid regions like the Limpopo Province, drought is the climate hazard that has the most detrimental effect on crop production. The most affected people are the resource-poor farmers whose productivity is threatened by frequent droughts. The quantification and monitoring of drought is of critical importance politically, economically and environmentally in most countries. Agroclimatological information is important to improve agricultural production as well as protecting the agricultural resources from deteriorating. The frequencies, means, extremes, deviations, exceedence of thresholds, spatial variability and trends of agroclimatological parameters are important for assessing and managing

agricultural risk. Many practices like the use of irrigation, improved cultivation and improved crop varieties have been developed over the years to adapt agriculture to climate variability and climate change, but agricultural productivity can further be increased, costs of production reduced and crop failures avoided through use of weather and climate information. In this project, analyses of agrometeorological information will support the farming community in better planning, improving preparedness and adaptive capacity, risk assessment, evaluation of current climate and agricultural interactions and simulation of future trends.

Estimated cost: R2 000 000
Expected term: 2014-2018

NEW PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD, FORAGE 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 strategic biofuel crops

University of KwaZulu-Natal (Pietermaritzburg)
No. 2491

The biofuel-related policy of the Department of Energy is encouraging biofuel manufacturers to source approximately 10–30% of feedstock grown by emerging farmers (and smallholder farmers). Hence, research is required to determine the expected water use and yields of grain sorghum and soybean produced in rural areas as well as to determine best agronomic practices for maximising attainable yield. To assist with agricultural extension services, information on which cultivars or hybrids are best suited to biofuel production in particular areas, as well as advice on how to manage fertility, weeds and pests/diseases is required. It is also important to develop enterprise budgets (on a per hectare basis) to determine the feasibility of feedstock cultivation in rural farming areas. It is generally accepted that water (and not land) is South Africa's scarcest natural resource. Given that South Africa is classified as a 'water-stressed' country, there is an urgent need to quantify the water use of feedstock required to meet the expected feedstock demand for biofuel production. The DWS are particularly interested in the impacts of water use associated with farming of communal land as well as knowing which feedstocks may need to be declared as Stream Flow

Reduction Activities (SFRAs). The current biofuels research project (WRC Project K5/1874) has highlighted the need to use crop coefficients, derived for biofuel feedstocks grown under local conditions, for modelling purposes. Research on feedstock water use under dryland conditions is required to assess the impact of communal farming on the availability of water resources for other downstream users.

Estimated cost: R4 000 000
Expected term: 2015-2020

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water use of agro-forestry systems for food, forage and/or biofuel production

Institute of Natural Resources NPC; University of Zululand; SRK Consulting (SA) (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); IRD

No. 2492

Agroforestry has been defined as a land-use system where woody perennial trees are integrated into the same land management unit as agricultural crops and/or animals. Agroforestry systems normally have two or more species, one of which is a perennial woody species and has two or more outputs (e.g. food, fuel and fodder). Furthermore it must be highlighted that such systems are ecologically and economically more complex than a mono-cropping system. Silvo-pasture is a system that integrates livestock farming with trees and crops and may involve planting of pastures. There is a need to improve food production and make more efficient use of available resources, especially land and water. With increasing populations and more pressure on land, increasing outputs per hectare and per unit of water is key to improving rural livelihoods. The integration of trees and shrubs into cropping systems has the potential to improve the use of available water by intercepting water that has percolated through the root zone of the agronomic crop. Furthermore trees and shrubs create microclimates, reducing evaporative losses through shading and canopy interception which reduces soil moisture fluctuations in the upper soil layer. Trees and shrubs can also increase the water-holding capacity of the soil through increased organic matter content. Leaf drop can also contribute to soil improvement and certain trees have the capacity to increase soil nutrient status through nitrogen fixation. In a situation where financial resources for investment in fertilizer are very limited, such interventions have the potential to improve crop yields. This research on agro-forestry systems therefore intends to develop environmentally sustainable solutions to improve rural livelihoods.

Estimated cost: R5 000 000
Expected term: 2015-2020

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Water use of crops and nutritional water productivity for food production, nutrition and health in poor rural communities

University of KwaZulu-Natal (Crop Science)

No. 2493

Reports indicate that food insecurity exists in South Africa at the household level, with about 14 million people residing in rural and peri-urban areas facing malnutrition. There is a need to improve agriculture in these areas so that people are empowered to produce enough food, broaden their existing food basket and improve diversity of nutrition. A WRC scoping study (2012) made significant progress in establishing a baseline for future studies on nutritional water productivity of crops. It noted that inability to make generalisations about food intake by rural people was due to insufficient data. It was also reported that home gardens in rural areas were currently underutilised owing to lack of sound agronomic practices. The report suggested improving home gardens through (i) proper crop selection, and (ii) use of best management practices. In short, it found that there was a gap in agronomic information on the range of crops that can be utilised in home gardens as food security crops. To this end, it recommended that such strategies should be aimed at improving the nutritional water productivity of these crops in rural areas. Such strategies should be multidisciplinary, because it is not just about increasing productivity of crops but also the impact on food intake trends and nutritional status of the rural poor. In this project such a multidisciplinary team would include agronomists, dieticians and sociologists working together through participatory research. This study will address challenges with food insecurity through empowering rural communities to grow their own crops based on their preference and using best practice management for improved nutritional water productivity.

Estimated cost: R4 000 000
Expected term: 2015-2020

Enhancing food security and nutrition of selected rural communities in Limpopo Province using high-yielding and water use efficient grain legume varieties

University of Limpopo (Plant Breeding and Insect Pest Management)

No. 2494

One of the ways to enhance sustainable food production, thereby enhancing food security and nutrition in drought-prone communities in Limpopo Province, is through the introduction and cultivation of high-yielding, disease and insect pest resistant, early maturing and water use efficient grain legumes such as cowpea, pigeon pea, Bambara groundnut, etc. Cowpea and early maturing pigeon peas are versatile crops which are known to thrive under low and erratic rainfall conditions where cereal crops cannot. Cowpea (*Vigna unguiculata* L. Walp) and pigeon pea (*Cajanus cajan*) are nutritious multipurpose grain legumes with tremendous potential, especially in rural areas of South Africa. These legumes are drought-tolerant and can thrive under low water stress and soil fertility. Cowpea is an important grain legume with very

high potential for production and improving dietary intake in South Africa. The seeds are rich in protein (24.8%), carbohydrate (63.6%), vitamins and other essential nutrients. Cowpea snacks and their derivatives are important traditional protein-rich products prepared and sold as foods and this can help improve the dietary intake of impoverished communities in South Africa. Cowpea can be easily intercropped with many crop species and contributes to soil improvement through nitrogen fixation. This project intends to show that introduction and cultivation of water use efficient and low-input grain legumes in rural communities where erratic rainfall is a major contributory factor to low yield will ameliorate the problem of food insecurity and malnutrition.

Estimated cost: R2 600 000
Expected term: 2015-2020

Up-scaling of rainwater harvesting and conservation to croplands and rangelands for food and renewable fuel (biogas) production

Agricultural Research Council (Institute for Soil, Climate and Water)

No. 2495

The application of appropriate rainwater harvesting and conservation (RWH&C) techniques on homestead gardens, croplands and rangelands in selected rural villages in South Africa could empower community members to produce their own crops using the arable land more productively and enhance livestock production using rangeland, hence contributing towards the reduction of household food insecurity. Since livestock production is already an important component of many smallholder farming systems, livestock manure can be used to produce biogas, which is a cost-effective, environmentally- friendly energy source. The biogas can be used for cooking, heating and lighting and is less harmful to environment than the smoke from open wood fires. However, for biogas generation, a sustainable water and manure supply is essential for the successful implementation and meaningful impact of this technology. Adequate water for the biogas digester can be collected from rooftops into tanks. The advantages of collecting water from roofs are that the roofs are physically in place and runoff is immediately accessible, the water collected from roofs is much cleaner than from land runoff and that most of the rainwater falling on the roof can be collected. Various rainwater harvesting technologies and biogas digesters are used at sites scattered around the country,; however, there is no single rural village where an integrated approach to economic development based on fodder, food, energy and water security is used. This emphasizes the importance of conducting a research and development project on the up-scaling of rainwater and conservation on croplands and rangelands for food and renewable fuel (biogas) production.

Estimated cost: R4 000 000
Expected term: 2015-2020

Towards enhancing contributions of inland fisheries to rural livelihoods: An empirical assessment of freshwater fish stocks, fisheries potential, market value chains, governance and co-management arrangements

University of the Western Cape (Institute for Poverty Land and Agrarian Studies – PLAAS); University of Cape Town; Rhodes University; South African Institute for Aquatic Biodiversity; University of Limpopo

No. 2497

A recently-completed baseline and scoping study published by the WRC found that inland fisheries contribute to the livelihoods, food security and employment of many rural women and men in South African informal economies. Recreational angling is by far the most developed, but access rights to the social and economic benefits from this sub-sector largely remain unequal. By contrast, commercial and subsistence inland fisheries are poorly developed despite several attempts dating back to the 1970s. This raises questions about the potential of inland fisheries to contribute to enhancing rural livelihoods. The management of the fishery to ensure sustainable utilisation of fish stocks over time, to promote the economic and social well-being of fisheries, should therefore be a top priority for provincial administrations. Although it has been suggested that stock enhancement may improve the productivity of small reservoirs, there is a paucity of information on fish stocks and fisheries potential for most dams. This knowledge gap critically hinders the capacity to determine appropriate stocking and harvesting levels for various dams. Objectives of the research project will also be to improve understanding about the nature of existing formal and informal market value chains (MVCs) associated with inland fisheries as well as the multiple user groups that access water and fisheries resources in dams; the economic value of inland fisheries in selected South African dams; factors affecting entry by rural women and men into lucrative MVCs associated with specific dams; and requisite institutional interventions for ensuring that MVCs associated with inland fisheries are sufficiently pro-poor.

Estimated cost: R4 000 000
Expected term: 2015-2020

Programme 2: Integrated water management for profitable farming systems

Long-run hydrologic and economic risk simulation and optimisation of water curtailments

University of the Free State (Agricultural Economics); DHI (SA); Technical University of Dresden

No. 2498

Currently the Mhlathuze catchment is undergoing compulsory licensing to reconcile imbalances in the catchment through a proposed curtailment of irrigators' water rights by 40%. If the assurance of supply to the irrigation sector in the Mhlathuze is to remain

the same, the extent of the curtailment may have a devastating impact on the financial feasibility of the farming operations with a direct impact on the local economy. A clear need exists to assist irrigation farmers with on-farm water use optimisation to cope with these water curtailments. Furthermore the NWRS-2 highlights the need for a more sophisticated approach through decentralisation and stakeholder participation to optimise operational management of infrastructure to address sometimes conflicting water requirements. Such a more sophisticated and general approach to water management will necessarily require some form of hydro-economic modelling. The research project will address the following knowledge gaps in order to model the impact of dynamic responses by irrigation farmers to curtailment within catchment-level management scenarios: (i) incorporating a better representation of dynamic irrigation water budget calculations into economic decision-making at the farm level to enhance the ability of the hydro-economic framework to quantify return flows and to improve agricultural water use optimisation; (ii) Improving economic modelling procedures to optimise dynamic structural (crop mix and irrigation technology choice) responses of irrigation farmers while taking the assurance of water supply within a state contingent framework into account.

Estimated cost: R3 000 000
Expected term: 2015-2019

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Guidelines for technology transfer to manage irrigation-induced salinity with precision agriculture

University of the Free State (Soil, Crop and Climate Sciences); Department of Agriculture, Environment and Rural Development; SASRI; Stellenbosch University

No. 2499

The salt load associated with irrigation is a major obstacle to sustained productivity for farmers in most semi-arid regions throughout the world, including South Africa. With the correct design and operation of irrigation and drainage systems, together with the implementation of best practices, sustainable irrigation is nevertheless possible, as advocated internationally and by research published by the Water Research Commission. The actual contribution of this knowledge to sustainable and productive irrigated farming systems is however questionable in the absence of appropriate management guidelines. Hence, there is a need to develop guidelines for technology transfer to manage the salt load associated with irrigation at farm and field level. With the ever-increasing availability and affordability of technology to support decisions within a field, through the adoption of precision agriculture or site-specific crop management, the opportunity also exits to apply these management guidelines at a much smaller scale for a decision support system (DSS) that incorporates guidelines and uses models for recommendations to better match water and

salt management, and soil and crop requirements as they vary in a field. This project will combine models that were developed with WRC funding, i.e., BEWAB and SWAMP, and advances in spatial delineation of site-specific management units (SSMUs), for example, soil sensing systems, terrain sensing, airborne and satellite optical imagery or proximal crop reflectance sensors, for development of salinity management guidelines at a farm level.

Estimated cost: R4 000 000
Expected term: 2015-2020

Programme 2: Impact assessment and environmental management of agricultural production

Seamless forecasting of rainfall and temperature for adaptation of farming practices to climate variability

University of Cape Town (Environmental and Geographical Science); University of Fort Hare; University of Venda; CSIR; Centre for Water Resources Research (CWRR); ARC (Institute for Soil, Climate & Water); South African Weather Service

No. 2496

The proposed research directly follows on from a previous WRC project (2012) which explored the application of weather and climate forecasts in agricultural decision-making. This included applying weather and climate forecasts within hydrological models to produce hydrological forecasts. The aim of this study is to develop an operational and robust climate–crop–water integrated assessment tool for the production of medium-scale agricultural forecasts (including water supply). The time scale of concern is monthly to a few months ahead with the particular intention to inform seasonal decision making. The spatial resolution of the project addresses community-scale issues and information that will improve response to climate variability. Consequent agricultural scenarios will be simulated through widely proven and extensively tested crop models, under common and expert-recommended management. These management alternatives could include some operational issues (deciding the implementation details of an action), but the major target is to better inform tactical decisions (deciding of actions not modifiable during the crop season, e.g., land–water–crop–fertiliser resource allocation, planting, etc.). However, the developing/modelling phase is only a part of a concretely applicable project. Stakeholder engagements from the inception to the end of the project will help to frame the research objectives and advancements into field constraints, e.g., maize yield estimates. The larger part of the project will encompass testing the approach in two smallholder farming communities, namely one in Eastern Cape and one in Limpopo. In addition to those smallholder farming communities, commercial farmers will be engaged in KwaZulu-Natal with respect to the application of hydrological forecasts in decision-making. These real-life experiments will demonstrate the feasibility and evaluate the benefits of the approach, as well as highlight the barriers and enablers of up-scaling this tool and disseminating its recommendations at a wider scale.

Estimated cost: R4 500 000
Expected term: 2015-2020

Emerging contaminants (veterinary pharmaceuticals and hormones) from agriculture in water systems around Cape Town and Stellenbosch, Western Cape

Cape Peninsula University of Technology (Chemistry); CSIR

No. 2500

Agriculture remains a significant source of emerging contaminants (EC) in the environment and in agriculture systems. The ECs that are currently the predominant sources of surface water contamination (relative to non-agricultural sources) and which are of potential concern include veterinary medicines such as antibiotics, anti-parasitic agents, and hormones (such as natural and synthetic oestrogens and androgens). The use of veterinary drugs for food production focuses on the control and improvement of animal health through therapeutic and prophylactic treatment. The disadvantage of this practice is that pharmaceuticals and their metabolites are released into the environment, finding their way to natural water systems and becoming potential risks to non-target organisms and to humans who may be exposed to such contaminated water. Livestock farming is prevalent in South Africa and especially in the Western Cape Province where it contributes substantially to the province's economy. The use of these chemicals in livestock farming in the province is widespread. Despite this, data on the presence of these chemicals in the Western Cape environment in particular is scarce or non-existent. Analysis of these data will be necessary for regulatory agencies in government departments and city authorities to develop guidelines for their sustainable use in agriculture in order to maintain public confidence in their water systems and food sources.

Estimated cost: R890 000
Expected term: 2015-2017

Quantifying and managing agricultural nitrogen and phosphorus nutrient pollution from field to catchment scale

University of Pretoria (Plant Production and Soil Science); University of the Free State; CSIR; Omnia Fertilizer

No. 2501

The DWS maintains a monitoring network of surface and subsurface water quality (including inorganic N and P concentrations) dating back to 1972. These data are extremely valuable for improving our understanding of N and P contamination levels in different parts of South Africa, but require extensive value-add. The potential further exists to identify hotspots where agriculture contributes significantly to these enriched N and P levels. The accurate quantification of agricultural contributions to surface and subsurface water N and P levels is, however, hindered by (i) the quality of models available and issues with upscaling from plot to catchment scale, (ii) the lack of adequate data for model parameterisation, initialisation and calibration, and (iii) the lack of adequate, independent datasets for model testing and verification. Plot-scale models simulate crop growth and soil water and nutrient dynamics fairly well, while catchment-scale models simulate N and P transport pathways over longer distances. The latter category of models runs the risk of

incorrectly simulating nutrient dynamics through over-simplification and the lack of feedback loops. As a result an interplay between more detailed plot-scale models and less detailed catchment-scale models is required. This project aims to build on work done in a previous WRC research project, to further improve the quantification of N and P pollution as well as develop and disseminate knowledge on appropriate mitigation measures.

Estimated cost: R4 000 000
Expected term: 2015-2019

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KSA 5: BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

SCOPE

This KSA provides strategic direction to the international cooperation, communication, marketing and branding goals of the WRC. Additionally, it supports the management of research projects, enhances innovation and provides the tools and processes for protecting technological developments. It also links the WRC's financial processes with technical fund management, while providing the necessary dissemination function to relevant stakeholders of research outputs and impact, and strategically positions the WRC within the local and international water sectors through its marketing and branding initiatives.

OBJECTIVES

The strategic objectives of KSA 5 are as follows:

- To improve knowledge uptake with the aim to increase implementation
- To position the WRC as a premier knowledge resource for all water-related issues, locally and internationally in order to enhance effective uptake of research
- To effectively manage the WRC research cycle for more efficient knowledge management
- To provide strategic research advice related to the water sector, R&D capacity, knowledge flow and ultimate impact

KNOWLEDGE DISSEMINATION

Enhancing public understanding of water research: *the Water Wheel*

The WRC aims to enhance public understanding of science through the publication of *the Water Wheel*. The magazine currently serves over 8 000 subscribers and is published every two months. The WRC published six issues of *the Water Wheel* in 2015/16.

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).

Distribution of WRC research and technology transfer reports

Table 1 indicates the number of e-reads and downloads of research reports from the WRC website in 2015/16, and Table 2 lists the most popular reports in 2015/16 in terms of number of downloads from the WRC website.

Table 1: Downloads and e-reads of research reports from the WRC website in 2015/16

	Downloads	E-reads
WRC research reports	18 452	3 615

Table 2: Most popular reports (downloads from website) in 2015/16

Report title	Downloads
Water purification works design	512
South Africa`s water research, development, and innovation (RDI) roadmap: 2015-2025	291
Guideline for the inspection of wastewater treatment works	252
National standards for drinking water treatment chemicals	235
A simple guide to the chemistry, selection and use of chemicals for water and wastewater treatment	194
The South African guidelines for sustainable drainage systems	180
Water sensitive urban design (WSUD) for South Africa: Framework and guidelines	179
Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries	143
Guidelines and training aids for the sustainable operation and maintenance of small water treatment plants	136
The Use of Chemistry, Isotopes and Gases as Indicators of Deeper Circulating Groundwater in the Main Karoo Basin	133
National wetland vegetation database: classification and analysis of wetland vegetation types for conservation planning and monitoring	119
The state of non-revenue water in South Africa	112
Guidelines for reducing water losses in South African municipalities	109
Theory, design and operation of nutrient removal activated sludge processes	100
Introduction to operation and maintenance of water distribution systems	93
Easy identification of some South African wetland plants	84
Conduit Hydropower development guide	82
Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands	80
Guides to the freshwater invertebrates of SA: Volume 8: Insecta II	77

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