WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW

2016/17

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INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2016/17, the WRC fulfilled its mandate to contribute positively to South Africa's ability to address its water challenges through research and development solutions. The research portfolio for 2016/17 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.

THE PRIMARY FUNCTION OF THE WRC IS TO:

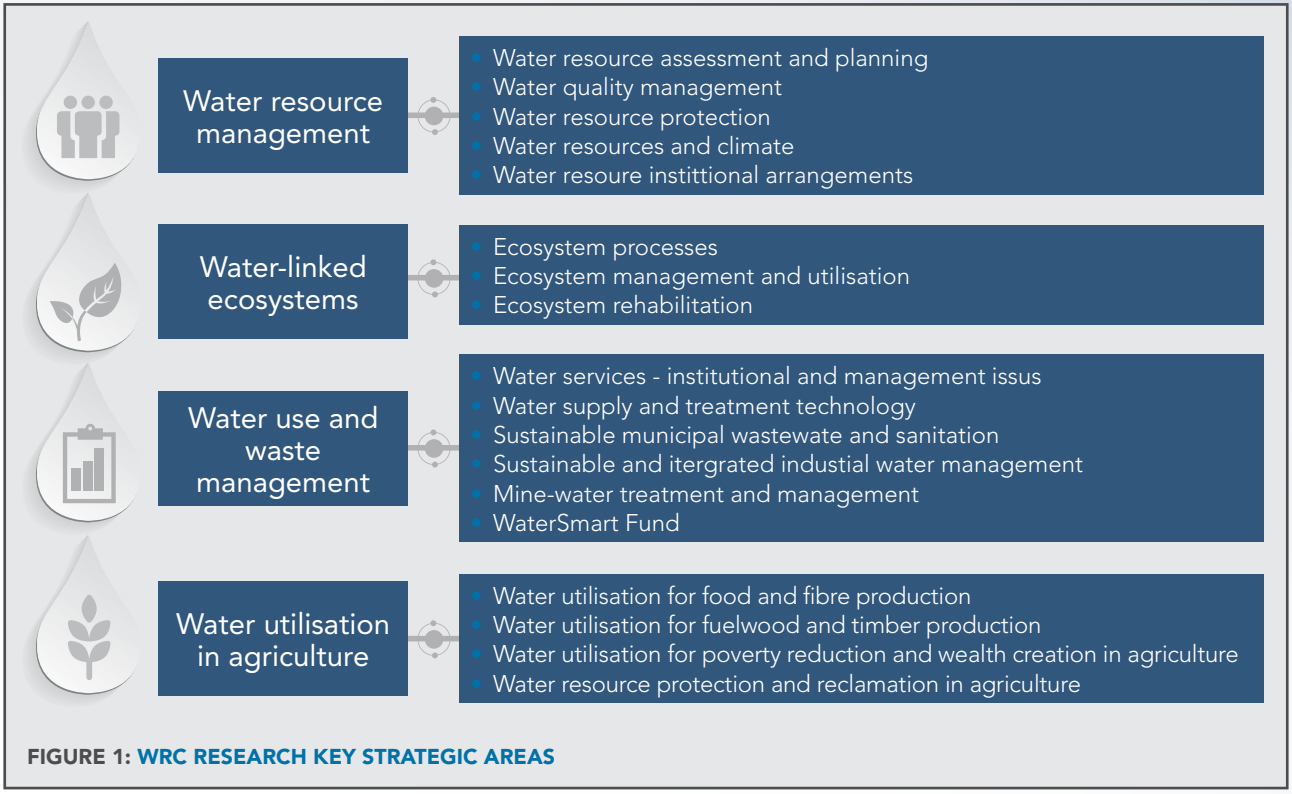

FIGURE 1: WRC RESEARCH KEY STRATEGIC AREAS

SUPPORTING RESEARCH PROJECTS

In 2016/17, the WRC initiated 106 new projects and also completed 87 projects. This represents a cumulative increase in the amount of new and finalised research projects funded over the past five years.

Over the past 5 years the WRC has finalised 426 research projects indicating a significant contribution to knowledge in the water sector (Figure 2). An average number of 85 projects were finalised per year, over the past 5 years. Over the same 5-year period 477 new projects were initiated (Figure 3), ensuring the continuous contribution of new knowledge to the sector. The large number of initiated projects was largely as a result of the WRC's new and existing funding partnerships.

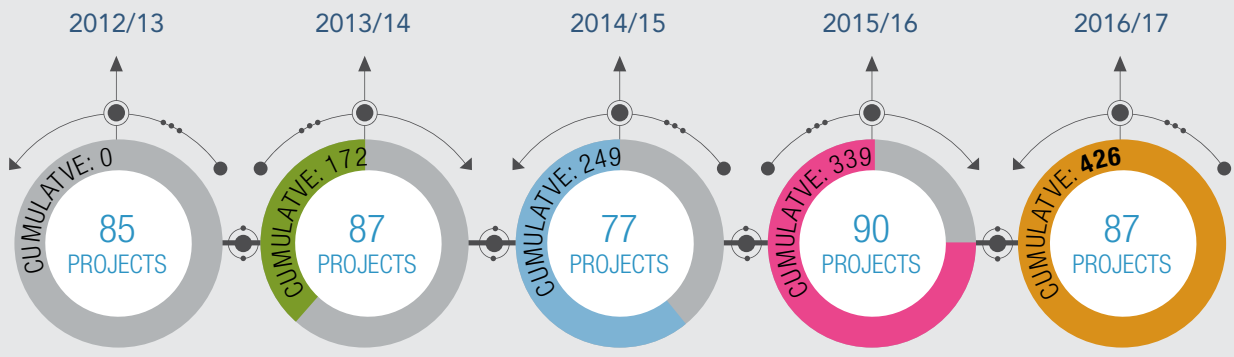

FIGURE 2. ANNUAL AND CUMULATIVE NUMBER OF PROJECTS FINALISED OVER THE PAST FIVE YEARS

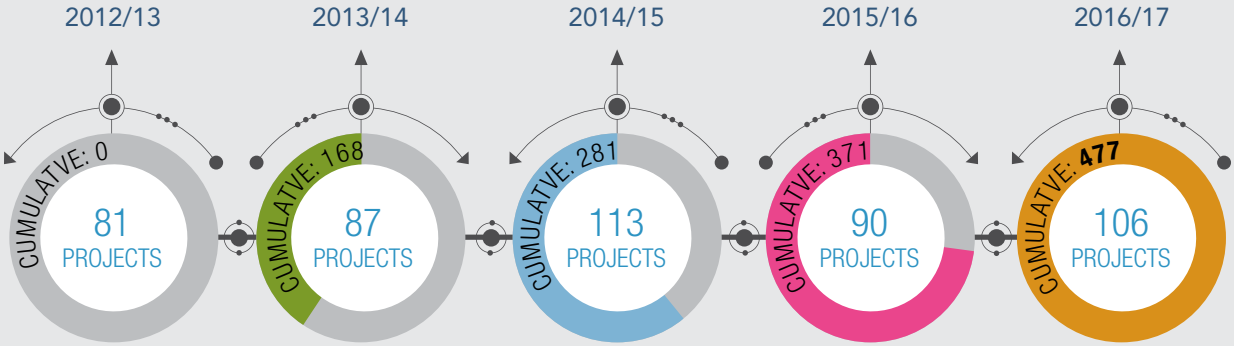

FIGURE 3. ANNUAL AND CUMULATIVE NUMBER OF PROJECTS INITIATED OVER THE PAST FIVE YEARS

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 (Figures 4 and 5), 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.

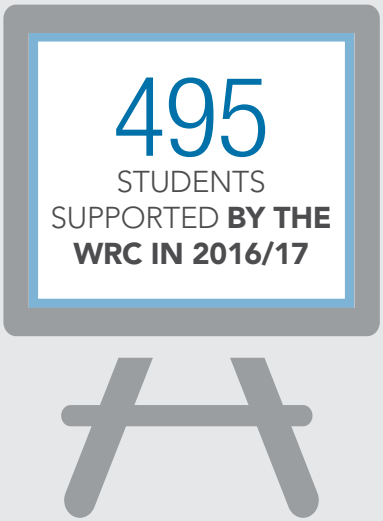

FIGURE 4. 495 – NUMBER OF STUDENTS SUPPORTED BY WRC IN 2016/17.

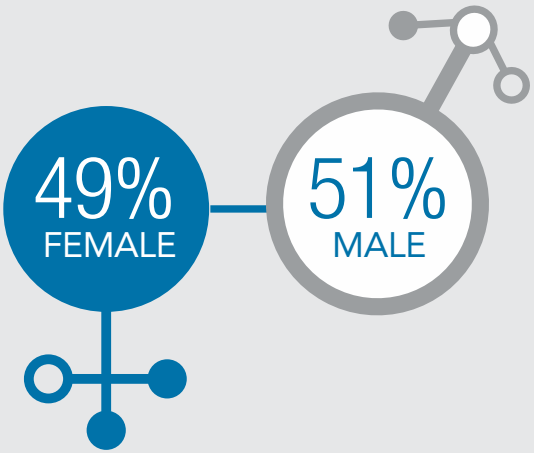

FIGURE 5. 49% PERCENTAGE OF STUDENTS ARE FEMALE (51% ARE MALE).

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 29 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 placing increased emphasis on community participation. The WRC is proud to report that it has 24 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 13 innovations were recorded in the past financial year.

UTILISATION OF RESEARCH FUNDS

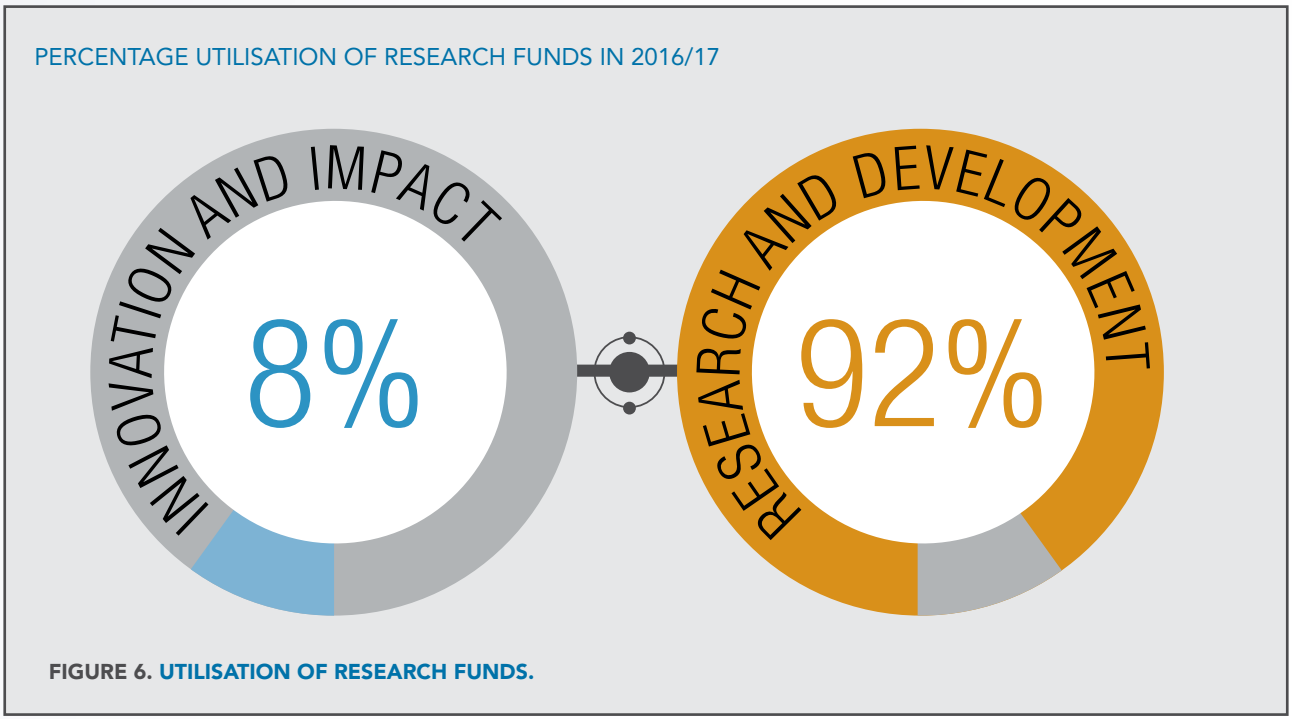

FIGURE 6. UTILISATION OF RESEARCH FUNDS.

The percentage utilisation of research project funds by the KSAs during 2016/17 indicates that approximately 8% (2015/16: 6%) was invested in projects that focused on Innovation and Impact, whereas 92% (2015/16: 94%) was invested in Research and Development (Figure 6).

The WRC has a renewed focus on achieving impact; as a public entity, we form 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 our 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

Going forward, the emphasis will shift to the Innovation and Impact Branch which will have an impact on the future utilisation of research project funds.

WRC RESEARCH PORTFOLIO 2016/17

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge (via its Research and Development Branch), over the 2016/17 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 2016/17

COMPLETED PROJECTS

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; University of the Witwatersrand (Centre for Water in the Environment); SANParks

2161

In order to strengthen governance of water resources, we need to make an array of shifts. While some of these require bold actions that impact on the overall manner in which we view development, some of the shifts involve tweaking of existing policies, institutional arrangements and legislation. The range of actions that need to be taken probably appear intimidating and politically difficult, but the recent crises in energy and water show us that it is necessary to make key changes. If changes are not made, history shows us that the broader society will stand up to force changes in the way they can. The changes envisaged in this report can be considered along the following dimensions: foundational matters – this speaks to the manner in which resources are viewed in broader development planning, and thus how government functions in a broader sense; and legislative, policy and institutional matters – these are governance changes within the water sector that will help improve the way we manage resources. Critically, this hinges on collaboration with non-traditional actors, such as the private sector and communities. More broadly, the changes envisaged require inputs from societal actors at key points, including devising of systems, oversight, implementation, and collaborations. It is important to note that the manner in which society has been involved in governance has been somewhat organic, but in order to strategically harness this opportunity, roles, responsibilities and replicable experiences need to be documented and engaged with. Overall though, the collaborations between government and society – particularly through initiatives like the SWPN-SA – are promising, and will be a key aspect of future governance frameworks.

Cost: R1 000 000
Term: 2012 – 2016

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

Centre for Water Resources Research (CWRR); CSIR; Australian National University

2320

Water plays a vital role in the well-being and economic activity of any society, be it within a rural or urban community, country or region. As a basic primary commodity, water contributes either directly (e.g. production of food) or indirectly (e.g. generation of electricity) to our livelihoods, lifestyles and wider economic activities. Water in a water-scarce country like South Africa is a catalyst to much societal and economic vulnerability embedded in our historical and cultural storyline. Furthermore, in a country where policy implementation is lacking in crucial areas, poverty alleviation is high on the socio-economic agenda and impacts of global change are severe. Such vulnerabilities should guide planning and decision-making. In South Africa the large number of impoverished people, a small middle class, and a limited number of wealthy result in strong inequalities. This is also true for levels of education, mobility and financial resources, and thus the population's vulnerabilities to risks are highly unequal. Therefore, water management in the sense of 'some for all forever' will need to incorporate much more localised and diverse issues with those of national economics and development. The information needed to address this is three-pronged:

- The impacts of change on the biophysical environment
- The socio-economic characteristics of the sector, group or individual
- The manner in which changes over time, in both aspects, impact on the overall growth and development of individuals, groups, catchments and the region

All three dimensions call for a wide range of data, knowledge and analyses which have to be regularly updated, incorporated and lead to specific management interventions that enable growth and development, empowerment and wellbeing of people, society and the nation. The project aimed at identifying sustainable development pathways for the establishment of CMAs in the different biophysical, social, economic, political and historical contexts of the diverse and highly unequal society of South Africa. By using conversations, workshops and other participatory tools it allowed the project team to create awareness and capacity for the different communities involved in CMA establishment. The repository as well as the guidelines will hopefully inform policy and lead to better decision making in the water sector.

Cost: R1 000 000
Term: 2014 – 2016

Water governance of groundwater and surface water resources in South Africa

Umvoto Africa (Pty) Ltd; Southern Waters Ecological Research and Consulting; IWR Water Resource (Pty) Ltd

2332

Several institutions are often responsible for groundwater management at different levels. These institutions are responsible for various activities and often require some level of inter- and intra-institutional cooperation. Ideally, multiple organisations, policies, legislation, plans, strategies and perspectives should be involved in water-related decision-making, which in turns creates complex leadership challenges. Globally, the lack of sustainable groundwater management can be ascribed to poor governance provisions. These include, but are not limited to, institutional arrangements and political will, including fragmented and overlapping jurisdictions and responsibilities, competing priorities, traditional approaches, rights and water pricing systems, diverging opinions, incomplete knowledge, data as well as uncoordinated information systems. Adding operational and maintenance issues, decision-makers often view groundwater as an unreliable resource and are hesitant to make significant investments in groundwater infrastructure and capacity. The conjunctive use and management of surface water and groundwater is a key strategy to meet the country's water demands. The project proposed here will aim to integrate groundwater governance provisions within the more established (surface) water governance provisions, as far as is possible, given the difference in current regulations, as well as the spatial and temporal scale differences. However, the proposal aims to go beyond the defined scope of works as it is believed that current shortcomings in the implementation of integrated water resource management on national and regional level must be addressed to achieve sound groundwater and surface water governance on local level.

Cost: R1 000 000
Term: 2014–2016

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

Crossflow Consulting (Pty) Ltd; African Centre for a Green Economy (Africege); Vulamanzi Water Law Advisers; University of Cape Town

2334

This project assessed the role to be played by catchment management agencies (CMAs) in water resource management and the optimal methodology to progressively empower them to do so. As such, this study, among other things, specifically examines the conditions necessary for CMAs to act as a 'Responsible Authority' for specific powers and functions. The indicators assist in determining when and under what conditions a CMA must become a responsible authority for specific powers and functions.

Cost: R1 000 000
Term: 2014 – 2016

Catchment management for the evolving priority in effecting subsidiarity principles in water management

AV Munnik & Associates; Pegasys Strategy and Consulting; AWARD; North-West University; Vaal Triangle Campus

2411

Catchment management forums (CMFs) are seen as places for enthusiastic participation, communities of practice in the making, and crucial to the devolution of water management to local stakeholders. They are also seen as exhausted, toothless talk shops, unrepresentative, undemocratic, haunts of the privileged, ignored by officials and a waste of time. Caught between reality and potential, theory and practice, they remain attractive to many people who are interested in participating in the governance of South Africa's water resources. This research project was designed to accompany the DWS revitalisation of catchment management forums, which was taking place as part of the roll-out of catchment management agencies. The project aimed to ensure that CMFs are well understood, resourced and appreciated as a critical level of governance capable of addressing the reduced stakeholder participation, and to find ways of enabling equal access to participatory structures and processes. The study started by examining the number of existing CMFs in the country, in whatever form they were in. The survey identified 81 CMFs, although the number is growing with the current roll-out of CMAs. CMFs differ radically from each other in composition, focus points, effectiveness and extent to which they address historical inequities. In general, the study has found CMFs to be vibrant spaces with keen participation from members and enjoying support from government departments, water boards, universities and non-governmental organisations. However, there are signs of participation exhaustion, ongoing conflict with and absence of local government, and frustration with a lack of compliance enforcement from government officials mandated to do so. The study also provided a model of functionality for CMFs based on five levels, i.e., logistical, communicative, community of practice, power to act and institutional resilience. Lastly the study found that a principled pragmatism is required in sustaining CMFs. Principled pragmatism retains the participatory and sustainability principles of IWRM but is pragmatic about what resources are available, and the technical and other constraints. This is a notion that was discussed in the form of forums – a structure the study also found necessary to establish in order to serve as a body bringing meta-issues to the DWS, in providing inputs on strategic matters that impact upon forums and in supporting the development of capacity across forums. The study produced ministerial and policy briefs listing all the key policy recommendations in establishing and sustaining CMFs.

Cost: R560 000
Term: 2014 – 2015

The path to successful water user associations in the NW dolomites

Jude Cobbing Consulting; Counterpoint Development; University of Pretoria

2429

Dolomite rocks in North West Province supply large volumes of very good quality groundwater (borehole water) for urban municipal water supply, dispersed rural water supply, irrigated agriculture, industry, and other uses. Unfortunately, these aquifers are poorly managed, and we are seeing falling groundwater levels, failing springs and the drying of wetlands. These issues in turn harm the assurance of water supply to towns such as Mahikeng, Zeerust and Lichtenburg, and can damage certain agricultural activities and other livelihoods. Groundwater supply from the dolomite aquifers has important backward and forward economic linkages to the regional economy. The Grootfontein aquifer near Mahikeng is a good example. Although it once used to be the main source of water for Mahikeng and Mmabatho, groundwater levels have now declined in the aquifer by an average of about 12 m below the level of the ground, and now the source is not reliable. This is because too much groundwater is pumped from the aquifer by irrigating farmers, and also by the boreholes supplying Mahikeng and some surrounding communities. If pumping quantities were lowered and groundwater levels were allowed to recover then the aquifer would be a much more reliable source of water. Mahikeng and DWS are currently spending a lot of money on upgrading the water treatment works at the Setumo Dam nearby, but much less attention is given to the Grootfontein aquifer. The Grootfontein aquifer can potentially hold more water than the Setumo Dam, and the water quality is much better than the dam water. The Water Users Association for Grootfontein was not approved years ago, and today there is no local organisation that is addressing the over-abstraction of groundwater at Grootfontein. If we could manage Grootfontein better, and other aquifers that are similar, we would be able to supply more people with good quality water and at a lower price. There is a lot of work to do, but in the end it will be cheaper than dealing with problems of drought and poor water quality. If we can improve the management of groundwater at Grootfontein, then this could also be used as a model for other areas in South Africa where groundwater management is a problem.

Cost: R335 000
Term: 2015 – 2016

Programme 2:
Compliance and enforcement

Citizen monitoring of the NWRS2

Environmental Monitoring Group; AV Munnik & Associates; Rhodes University

2313

This project piloted an approach that empowers community-based and other civil society organisations 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 and other relevant water policy. Water quality and the inclusion of spiritual water users, timber plantations and ecosystem functioning water demand management (WDM) within the context of climate change are areas in the NWRS2 which were used as case studies to develop an in-depth understanding of how South African water policy is monitored and

implemented, and what role civil society can play in these processes. Also, the study explored the potential for social learning processes to build capacity in civil society, and produce guidelines for use in strengthening civil society participation in water resource management.

Cost: R1 764 300
Term: 2014 – 2017

Programme 4:
Climate change and water resources

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

Centre for Water Resources Research (CWRR); University of Pretoria; Pegram and Associates (Pty) Ltd; University of Arizona

2323

For many field and modelling applications, accurate estimates of soil water (SW) are required, but are often lacking. Modelled estimates of SW are often used without proper validation and the verification of the results is questionable. In addition, remotely-sensed (RS) products are becoming more widely used in hydrological modelling. However, RS SW measurement is faced with the difficulty of 'seeing' below the soil surface and penetrating the aerial plant canopy layer. This still presents a major source of uncertainty in many hydrological applications where SW forms the interface between the atmosphere and the vadose zone and ultimately streamflow generation. Water resource management, crop modelling, and irrigation scheduling all require accurate, spatially distributed, daily estimates of SW and total evaporation (ET) from catchment to national scale. One of the major challenges facing providers of SW products is validation. This project was initiated to provide a spatially explicit validation procedure for the 1-km grid of SW and ET produced by the SAHG at UKZN and other global climate models. The recent development of cosmic ray probes (CRP) was timely and provided a technology previously unobtainable, which fitted perfectly with the spatial resolution of this project. The CRP is a new and innovative in-situ instrument, capable of measuring SW at an intermediate scale. The CRP estimates were used to validate modelled SW estimates and the back-calculation of SW from relative evaporation estimated from the SEBS Model. The back-calculation of SW from relative evaporation and evaporative fraction, estimated using the SEBS model, looked like a promising technique. The spatial resolution was less than the catchment area and the measurement depth was representative of the root zone of the vegetation (0.50 m). Therefore, this product would have the least horizontal and vertical scaling issues, when validated against the CRP. Although the back-calculation method results in SW estimates on a 30-m spatial grid, the temporal resolution of the imagery used is 16 days and performed poorly against the CRP validation data. It is recommended that further research is required into the measurement of SW from RS products and the CRP.

Cost: R1 000 000
Term: 2014 – 2016

Open water evaporation measurement using micrometeorological methods

University of KwaZulu-Natal (Pietermaritzburg); Department of Water and Sanitation

2335

For Midmar Dam in KwaZulu-Natal, South Africa, a Penman-Monteith model (DPMETHS), that uses land-based meteorological data, was used to estimate daily open water evaporation. The DPMETHS model estimates, accumulated annually, exceeded 1 300 mm during El Niño years. The maximum annual evaporation for the 1963 to 2014 period exceeded 1 400 mm with a minimum of 975 mm. Statistically, there has been no significant change in annual evaporation for the 1963 to 2014 period. The agreement between Symon's pan (annual) open water evaporation (available for 1976 to 2006) and the DPMETHS model estimates was poor for the period 1976 and 1993 with the Symon's pan significantly underestimating compared to the DPMETHS estimates. For the period 1994 to 2006, the agreement was improved. In a field above-water study at Midmar Dam, in spite of the reasonable Monin-Obukhov similarity theory (MOST) vs, eddy covariance (EC) comparisons, more than 30% of the EC evaporation measurement data collected were discarded as a result of application of the data quality assurance protocols. It was therefore not possible to use the EC method to obtain continuous 30-min measurements of evaporation. Unlike vegetated surfaces, for which there is stomatal control of evaporation during the daytime and virtually no evaporation at night due to stomatal closure, open water surfaces are not constrained. MOST evaporation measurements demonstrated that 44% of daily total evaporation occurs at night with 56% during the daytime. The MOST measurements demonstrated the significant wind control influence on the evaporation estimates. Surprisingly too, maximum wind speeds generally occurred at night with the night-time wind run comprising 42% of the total wind run. Over land, vegetation would offer more resistance to wind so wind effects on evaporation would be reduced, compared to open water surfaces. Evaporation was the greatest component of the energy balance by far, representing about 75% of the net irradiance, 12.8% for water-stored heat flux and 12.1% for sensible heat flux. This study has demonstrated the importance of above-water weather data collection for evaporation estimation. Future research should focus on collecting data above open water for an extended period of time that includes a full summer season, winter and summer rainfall areas and small and large dams.

Cost: R1 100 000
Term: 2014 – 2016

Programme 5:
New water and water security

Sustainability indicators and decision framework for sustainable groundwater use

Delta-H (Pty) Ltd; University of the Free State (Institute for Groundwater Studies); Groundwater Africa

2311

The well-documented and scientifically accepted

theoretical principles of groundwater flow theory dictate that 'water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in the recharge, or a combination of these changes' (Theis, 1940). The associated decrease in discharge or increase in recharge has been termed 'capture' of water, and it is the ability of aquifer pumping to capture discharge and enhance recharge that dictates the aquifer's yield. It follows that an assessment of the sustainability of groundwater abstraction would quantify these changes in the flow regime, and determine whether the changes and their associated impacts are considered acceptable, termed here the capture principle–based approach to groundwater sustainability. However, many current tools to support groundwater management broadly apply water balance type calculations for aquifer yield assessments, often at quaternary catchment scale, and aquifers (or catchments) with high use compared to recharge are generally identified as 'stressed' or 'over-used'. The approach can limit groundwater development based on a perceived stress. Impeding the implementation of the capture approach to sustainability, is the fact that the approach is intertwined with adaptive management. Management must proceed on less than ideal information, and decisions must be adjusted as groundwater use continues. This is awkward to regulate. The ultimate purpose of the project was to promote the capture principle approach to sustainable groundwater use. The project proposed the development of a tool (decision framework) that could facilitate the translation of theoretical hydrogeological principles for sustainable groundwater use based on the capture approach into practice.

Cost: R700 000
Term: 2014 – 2017

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Update of the Groundwater Sampling Manual

University of the Free State (Institute for Groundwater Studies)
2428

The Department of Water and Sanitation (DWS) is custodian of water resources and responsible for coordinating investments in water infrastructure. There are about 250 water schemes in South Africa that DWS is responsible for. Other water infrastructure schemes that the state has responsibility for comprise those that are transboundary in nature, including the Lesotho Highlands Water Project (LHWP). It is estimated that the current replacement value for the water infrastructure is about R139 billion, and that South Africa requires at

least R1.4 billion investments per annum to maintain the current water infrastructure. This funding challenge has exacerbated the water management situation in the country. This study sought to develop understanding of the perceived challenges and constraints faced by the private sector, which prevents them from harnessing the opportunities of investing in the water and sanitation sector in South Africa. This was based on the premise that by unpacking these perceived challenges, a clear picture of the investment opportunities in the sector might be unveiled to make a business case for investments in the sector. The main outcome of this study reflects the fact that private sector involvement in the financing of water infrastructure is still quite poor, with the public sector still bearing the large cost of infrastructure financing. In cases where the private sector is involved, it is on the basis of financing large infrastructure programmes that have been guaranteed by government. The lack of clarity in the regulatory framework in the financing of water infrastructure has exacerbated the perception of risk by the private sector and resulted in their participation being quite limited. The financial status of local municipalities has also hindered them from effectively using market mechanisms for fundraising for their infrastructure programmes, because of poor balance sheets.

Cost: R600 000
Term: 2015 – 2017

THRUST 4: WATER RESOURCE PROTECTION

Programme 2:
Land-water linkages

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
2441

The study area focuses on WSD interventions for the area covered by the Cape Flats aquifer, and included the surface water catchments to the east of the Kuils River. Available data and information on the hydrology and hydrogeology of the study area is described. In order to define the surface water contributions to the Cape Flats aquifer, it is necessary to account for the way in which effective rainfall is partitioned in the water balance, into its evaporative, runoff, storage and infiltrating components, as well as the separation of runoff into overland flow and stormwater flow through the stormwater network. The primary surface water input into the groundwater component of the Cape Flats aquifer model is infiltration, and it is through solving of the aforementioned components of the water balance

that infiltration is best estimated. Existing surface water models (in PCSWMM) were sourced, and updated, for the northern and eastern catchments, and a new model was established for the southern catchment. The models were used to quantify spatially disaggregated infiltration across the Cape Flats for normal, wet and dry years. A numerical groundwater model was established for the Cape Flats aquifer (in SPRING). Scaling the surface water model-derived infiltration to absolute recharge, a spatially disaggregated recharge dataset has been generated. This recharge dataset improved numerical model calibration, suggesting that inclusion of the urban influences on infiltration is necessary to accurately replicate observed water levels. The WSD scenarios tested illustrate that the Cape Flats aquifer could provide a significant resource for bulk abstraction (~10 million m^3/a for the wellfield scenarios applied), in addition to maintaining increased dispersed abstraction (~7 million m^3/a). Although the ecological impact of reduced groundwater contribution to baseflow is not considered here, this is likely to be minimal since several rivers currently have almost no ecological functioning (canalised, degraded), particularly in comparison to abstraction in pristine areas or in areas where reduced baseflow may impact utilised surface water resources. The simulation results illustrate that the source of groundwater for bulk abstraction (protection zone) is a relatively small area around the abstraction sites. The WSD scenarios tested also illustrate that point injection does not appear to be beneficial to bulk abstraction. Aerial infiltration within the cone of dewatering is likely to provide better results.

Cost: R1 000 000
Term: 2015 – 2016

THRUST 1:
WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1:
Water governance and institutional reforms

Institutional arrangements for implementing water equity mechanisms in South Africa

Prime Africa Consultants (previously CIC International)

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.

Cost: R 1 162 600
Terms: 2013 – 2016

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

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

Cost: R1 000 000
Term: 2015 – 2016

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
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)

Cost: R1 303 000
Term: 2014 – 2017

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

GreenCape; University of Cape Town
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

Cost: R2 059 672
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

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

Cost: R1 788 000
Trm: 2015 – 2017

Water accounts for South Africa

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

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 water tables and accounts in Excel to enable ease of use for integrated impact and policy analysis

Cost: R1 800 000
Term: 2015 – 2017

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

University of Fort Hare; Rhodes University

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

Cost: R2 000 000
Term: 2015 – 2018

The impacts of commercial plantation forests on groundwater recharge and streamflow

CSIR

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

Cost: R1 605 960
Term: 2015 – 2018

The hydrogeology of Groundwater Region 39

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

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

Cost: R400 000
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
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

Cost: R2 727 800
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
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

Cost: R250 000
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

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

Cost: R3 500 000
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

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

Cost: R2 500 000
Term: 2015 – 2018

Upstream–downstream hydrological linkages in the Limpopo River Basin

CSIR; Rhodes University (IWR)

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 set up 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

Cost: R1 700 000
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
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

Cost: R1 400 000
Term: 2015 – 2018

Programme 3:
Water resource planning and infrastructure

Enhancements to WR2005 study (completed for the WRC in December 2008)
SSI
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.

Cost: R450 000
Term: 2010 – 2011

Programme 4:
Climate change and water resources

Managing limits in skill for seasonal climate forecasting

University of Cape Town
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

Cost: R2 025 640
Term: 2013 – 2017

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

CSIR
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

Cost: R600 000
Term: 2014 – 2016

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

University of the Western Cape
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

Cost: R1 200 000
Term: 2014 – 2017

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

South African Weather Service
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

Cost: R1 113 000
Term: 2013 – 2017

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

University of Cape Town
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

Cost: R1 150 000
Term: 2014 – 2017

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

South African Weather Service
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

Cost: R1 080 000
Term: 2014 – 2017

Ocean impact on southern African climate variability and water resources

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

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

Cost: R1 540 000
Term: 2015 – 2018

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

University of Cape Town; CSIR

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

Cost: R1 271 360
Term: 2015–2018

Predictability of hydroclimatic variability over eastern South Africa under climate change

CSIR
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

Cost: R1 257 000
Term: 2015 – 2018

Programme 5:
New water and water security

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
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

Cost: R1 980 000
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
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

Cost: R1 400 000
Term: 2014 – 2017

THRUST 3:
WATER QUALITY MANAGEMENT

Programme 1:
Water quality monitoring

Encouraging citizens' water quality management through subcatchment forums

Mvula Trust

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

Cost: R600 000
Term: 2012–2014

Water resources management in South Africa: towards a new paradigm

Rhodes University

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

Cost: R5 000 000
Term: 2013 – 2017

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
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

Cost: R1 500 000
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)
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

Cost: R2 000 000
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

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

Cost: R438 600
Term: 2015 – 2016

Geophysical delineation and monitoring of AMD in COH

CSIR; Tshwane University of Technology

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

Cost: R720 240
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
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

Cost: R2 000 000
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
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

Cost: R780 000
Term: 2015 – 2017

Multi-2array sensor technology for polycyclic aromatic hydrocarbons screening in wastewater
University of the Western Cape; City of Cape Town
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

Cost: R730 000
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
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

Cost: R3 000 000
Term: 2015 – 2018

Programme 2:
Water quality modelling

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

University of KwaZulu-Natal (Howard College Campus)
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

Cost: R667 000
Term: 2014 – 2017

Cholera monitoring and response guideline

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

Cost: R1 260 000
Term: 2015 – 2018

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

Rhodes University; Amatola Water
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

Cost: R898 737
Term: 2015 – 2018

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
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

Cost: R850 000
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

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

Cost: R1 715 150
Term: 2012 – 2015

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

Hydro Aqua Earth

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

Cost: R1 000 000
Term: 2012 – 2015

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

GCS; University of the Western Cape

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

Cost: R510 000
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

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

Cost: R665 000
Term: 2014 – 2017

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

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

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

Cost: R500 000
Term: 2015 – 2017

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

Emanti Management (Pty) Ltd; SHE Legal
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

Cost: R854 160
Term: 2015 – 2017

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
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

Cost: R2 500 000
Term: 2014 – 2017

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
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 publicly accessible access point for all deep groundwater data

Cost: R1 000 000
Term: 2015 – 2017

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

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

Cost: R1 000 000
Term: 2015 – 2018

NEW PROJECTS

THRUST 1:
WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1:
Water governance and institutional reforms

Historical and status quo evaluation and proposed policy considerations for judicial revision (appeal and review) of administrative actions under statutory water resources management in South Africa

Vulamanzi Water Law Advisers

2513

Project aims:

- To develop an understanding of the current status quo of judicial review (revision and appeal) of water management actions, and understand the shortcomings, both legally and operationally, of the current system
- To understand the legal and operational requirements for judicial review in water management
- To consider possible alternatives for a legally and operationally functional statutory review mechanism, in view of international best practice
- To propose a model for a suitable judicial review system for water management, which is both legally and operationally functional, to address the current non-functioning mechanism

Cost: R300 000
Term: 2016–2017

Water allocation for productive use – policy and implementation: A case study of the Black emerging farmers in the Breede-Gouritz Catchment Management Area, Western Cape, South Africa

Cape Peninsula University of Technology; University of the Western Cape; Breede-Gouritz Catchment Management Agency; Wageningen University (The Netherlands)

2530

Project aims:

- To explore the case of Black emerging farmers in the Breede-Gouritz Catchment Management Agency in the Western Cape, South Africa, between 2005 and 2015, by identifying and analysing the legal and institutional difficulties experienced by Black emerging farmers (BEF) accessing water use for productive purposes
- To define the role and influence of the bureaucracy as experienced by Black emerging farmers (BEF) in accessing water use for productive purposes compared to that of successful White farmers
- To plot and interrogate the role and effect of the intersection of bureaucracy and law impacting access to productive water and reform
- To contrast the experience of Black emerging farmers with those of commercial White farmers in accessing

water use for productive purposes to determine whether the new dispensation had brought about the expected redress
- To develop a means to contribute to the development and improvement of the status quo as experienced by the BEF
- To contribute to the ongoing cycle of review of the national water dispensation

Cost: R700 000
Term: 2016 – 2018

The challenge of inclusive growth in South Africa: Determinants and outcomes
University of Cape Town
2601

Project aims:
- Describe the nature of South Africa's growth-poverty-inequality trajectory since 1994
- Understand and estimate changes in asset and service poverty amongst households since 1994

Cost: R299 942
Term: 2016 – 2017

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Integrated land use and water use in water management areas, with a view on future climate and land use changes
CSIR; Stellenbosch University
2520

Project aims:
- To identify and quantify the current relationships between water use and land use at national and WMA/provincial/municipal scales
- To relate historic (15 years or longer) changes in water use to climate variability and land use changes
- To develop scenarios of future land use changes and model their likely effects on water use

Cost: R2 160 000
Term: 2016 – 2019

The hydrogeology of Groundwater Region 41: Eastern Great Karoo
Geowater IQ (Pty) Ltd
2525

Project aims:
- Contribute to the current knowledge of groundwater occurrence in the Karoo Basin

- Develop a guide for future groundwater development and regulation

Cost: R270 000
Term: 2016 – 2018

Continued hydrometeorological monitoring at the Two Streams experimental catchment for clear felling of the Acacia mearnsii stand

SAEON; University of KwaZulu-Natal (Pietermaritzburg)
2780

Project aims:

- Maintain and install monitoring equipment needed to estimate the water budget of Acacia mearnsii, and prepare for clear-felling in October
- Continue monitoring and data quality control activities until clear felling of Acacia mearnsii
- Determine the impacts of mature Acacia mearnsii on the water balance

Cost: R600 000
Term: 2017

Programme 2:
Surface water / groundwater hydrology

Ideas toward water-sensitive settlements

Envirosource; University of the Witwatersrand; University of Cape Town; University of Johannesburg
2519

Project aim:

- A water-sensitive approach to planning and design defines a new paradigm in integrated water cycle management, which aims to ensure that water is given prominence within the settlement design processes
- Assess the potential of settlements as their own potential water supply catchments, meaning access to a range of different water sources at a diversity of supply scales
- Assess the potential for the built environment (settlement) to supplement and potentially support the functions of the natural environment and human activities, e.g., agriculture
- Enable ideas of socio-political capital towards sustainability and the community's decision-making behaviour toward water-sensitive design

Cost: R380 000
Term: 2016 – 2018

An integrated early warning forecast system for wet seasons and their relationship to flooding events: A predictability study in support of hydrological applications

CSIR
2522

Project aims:

- To expand on the current CCAM seasonal forecasting capability of the CSIR through coupling with the Coupled Atmosphere-Biosphere Land Exchange

(CABLE) dynamic land surface model and the utilization of its river routing scheme; the horizontal resolution of the CCAM in seasonal forecasting mode will be 200 km
- To expand the 15-km resolution 7-day forecasts of CCAM to the medium-range of 14 days; CABLE coupling and river routing for 14-day forecasts to be implemented
- To further enhance the high resolution (4 km) weather forecasting capability of the CCAM by producing flow forecasts through the river routing scheme of CABLE; area of interest is the north-eastern interior of South Africa and adjacent countries
- To develop statistical downscaling schemes for seasonal, medium-range and 48-hour forecasts of river flows over the north-eastern interior of South Africa by making use of the daily flow data hosted by the Department of Water and Sanitation

Cost: R900 000
Term: 2016 – 2018

Nanosensors for oceans and atmospheric research

University of the Western Cape; Department of Environment Affairs (Marine and Coastal Management)
2533

Project aims:

- Development of novel polyamic acid nanocomposites modified with graphene: unique reactivity of polyamic acid (PAA) is induced by prevention of the cyclization of the reactive soluble intermediate into polyimides at low temperature to design polymer-assisted nanostructured materials; a new class of conductive polymers that may be functionalised by incorporation of metal nanoparticles, quantum dots or copolymerisation (using polypyrrole) will be produced for selective electrochemistry
- Development of a Cyt C nanosensor, the detection of NO using the graphene-modified polymeric composites as well and those infused with metal nanoparticles
- Evaluation of the partition coefficients of CO_2, NH_3 and S_xO_y species at individual polymer/graphene nanocomposite interfaces; the gas(air) partition coefficients for CO_2, CH_4OH, CH_3CH_2OH will be determined using the shake flask method and UV/vis analysis and construction of calibration curve for quantification; the sensitivity of the polymer metal nanocomposites for these analytes in solution will be determined electrochemically and the sensor response for CO_2, CH_4OH, CH_3CH_2OH will be determined using potentiometric response protocols
- Evaluation of sensor array sensing formats for multicomponent analysis of the chemical species for which the electrochemical analysis protocol will be established
- Evaluation of array sensing in real sample analysis, in partnership with the scientists at Department of Environmental Affairs research laboratories, sensor array technologies will be applied to the determination of concentration profiles for CO_2, NH3, NOy and S_xO_y species, in and above ground and in seawater

Cost: R300 000
Term: 2016 – 2018

Programme 3:
Water resource planning and infrastructure

Developing practical documents to aid design and construction of liquid-retaining structures and making research provision for the next revision of SANS 10100-3

Stellenbosch University (Civil Engineering); University of KwaZulu-Natal (Howard College)

2514

Project aims:

- To provide guidance documents to clients, design engineers and contractors that would assist them in delivering economic, safe, watertight and durable structures, avoiding the common pitfalls in design and construction
- To conduct focused training seminars to disseminate the content of the guidance documents to clients, design engineers and contractors
- To identify outstanding issues influencing the effective procurement, design, construction and operation of liquid retaining structures, related water supply structures and infrastructure and to develop a framework for future initiatives required to address these
- To conduct the necessary research required to allow an informed decision regarding which crack width prediction models and limits for load-induced and restraint cracking, respectively, should be included in the next revision of SANS 10100-3, due in 2020 (these have a direct and significant influence on the economy of the structural design)
- To conduct the necessary research required to allow the provision of better design guidance on the T1 (heat of hydration) and T2 (seasonal variation) values used in design for early age and long-term thermal cracking (thermal cracking is often problematic, necessitating unexpected and costly repair work).
- Contribute to capacity building by supporting one PhD student, two MEng students and several final-year student projects, who will be involved in related research
- Development of specialisation amongst staff members at Stellenbosch University (three members) and the University of KwaZulu-Natal (one member)

Cost: R1 500 000
Term: 2016 – 2019

Programme 4:
Climate change and water resources

Impact of the predictability of continental tropical lows on hydrological modelling: current state and future projections

University of Pretoria; University of Limpopo; South African Weather Service; CSIR

2510

Project aims:

- Develop an objective identification system for continental tropical low-pressure systems based on their circulation criteria and dynamical characteristics using re-analysis data
- Describe the temporal and geographical variability

of continental tropical low-pressure systems over subtropical southern Africa within the broader climate variability in the region
- Determine the contribution of CTL to rainfall over South Africa
- Provide case study examples of extreme rainfall producing CTLs
- Investigate the forecast uncertainty associated with CTLs using atmospheric flow fields from ensemble predictions and compare these results to forecast uncertainty associated with heavy rainfall producing cut-off lows
- Investigate the impact of forecast uncertainty on stream flow in the Limpopo River basin by using rainfall prognosis from ensemble predictions
- Determine the projected changes in frequency of occurrence and location of CTLs and the associated rainfall in a future climate

Cost: R719 800
Term: 2016 – 2019

Economic study of assurance of supply requirements for water resource management

WRP Consulting Engineers (Pty) Ltd; Conningarth Economists

2517

Project aims:

- To develop a methodology for assessing the assurance of supply requirements of various water user sectors based on economic grounds; case studies will be used, with particular reference to the agricultural sector
- Results will be used to develop assurance of supply criteria to enable the economically optimal management of water resources (local, regional and national)

Cost: R760 000
Term: 2016 – 2018

THRUST 3:
WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1:
Water quality monitoring

Assessment of potentially toxic elements and their species in selected water systems in Limpopo Province

University of Limpopo; Tshwane University of Technology; University of Johannesburg

2515

This project aims to assess the levels of potentially toxic elements (V, Mn, Pb, Cd, Ni, Cu, Fe, Zn, Cr, As and Se) and their species in wastewater, water and sediment samples collected from selected rivers in Limpopo Province, South Africa. The specific objectives are:

- To collect water and sediment samples from selected sites
- To develop a sample mineralisation method for digestion of wastewater and sediment samples using microwave-assisted digestion system for the determination of total concentrations of potentially toxic elements
- To develop sample preparation procedures, solid phase extraction (SPE) and supported liquid membrane (SLM) using chemical and biological adsorbents for sample pre-concentration and speciation of potentially toxic elements
- To apply the sequential extraction procedure proposed by the European Standard, Measurements and Testing (SM & T) program, formerly the Community Bureau of Reference (BCR), for fractionation of potentially toxic elements in river sediments
- To develop microwave-assisted sequential extraction procedure for fractionation of the elements in sediments in less time, while using smaller volume of reagents
- To validate the developed/improved analytical methods by using standard reference materials (SRMs)
- To determine the levels of potentially toxic elements and their species in water and sediment samples using F-AAS, ICP-MS and HPLC-ICP-MS
- To evaluate the potential health risks that arise from the consumption of contaminated water

Cost: R1 037 000
Term: 2016 – 2019

Emerging and persistent contaminants/pathogens: monitoring methods development

University of the Western Cape; Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology

2521

The aim of the project is to investigate and develop detection/monitoring methods for a large range of emerging and persistent contaminants:

- To scan the literature for possible emerging micropollutants identified in other provinces in South Africa

- To develop clear, concise and suitable effluent sampling procedures
- To develop suitable extraction procedures for the detection of a variety of emerging micropollutants
- To develop a new analytical method based on nanosilver-coated track-etched membranes that can be used for the identification of the emerging micropollutants in water samples by surface enhanced Raman spectroscopy (SERS)
- To determine the effect of different matrices upon detection and quantification of emerging micropollutants
- To determine the limitation of sampling, extraction and analytical techniques for detecting different categories of emerging micropollutants in water samples
- To compare the new analytical method with the existing ones in order to determine the advantage of the new method over the existing ones

Cost: R1 635 000
Term: 2016 – 2019

Improving drought and flood early warning, forecasting and mitigation using real-time hydroclimatic indicators

University of Cape Town

2618

The central and innovative hypothesis of the project is that new hydro-climatic observational networks, such as agro-meteorological and weather radar networks, can be integrated with conventional observational networks and models, thus allowing for better spatio-temporal estimation of the severity of droughts and floods, facilitating their management. The main objective of IMDROFLOOD is to enhance flood and drought risk management at the catchment level through the development of novel flood and drought information tools.

Cost: R754 491
Term: 2016 – 2019

Scoping study: development of an inclusive terms of reference to improve licensing conditions by better understanding and application of RQOs used to improve resource class, under its current application in the Vaal Catchment

Rhodes University

2782

Project aims:

- To consult with all relevant stakeholders including: DWS (all relevant units), the Upper Vaal CMF, small industries, and Sasol
- To frame the scope of the case study that will investigate the methods and scientific defensibility for setting standards so as to meet RQOs
- To ensure buy-in by DWS (all relevant units) and stakeholders concerning the case study river reach/es
- To produce a TOR for an Upper Vaal Case study with agreed objectives, timelines and deliverables

Cost: R100 000
Term: 2017

THRUST 4:
WATER RESOURCE PROTECTION

Programme 1:
Source water protection

Sentinel-3 validation for water resources protection (S3VAL)

CyanoLakes; CSIR; University of Cape Town

2518

Project aims:

- To validate measurements of water colour (radiometry) and geophysical variables from the Sentinel-3 Ocean and Land Colour Instrument during instrument commissioning and afterwards
- To collect high-quality datasets from locally developed, autonomous moored platforms to be used for validation of satellite-based measurements and development and testing of geophysical retrieval algorithms
- To build human capacity/expertise in water remote sensing to meet the demands of the private, public and research sectors
- To assess the data quality, absolute radiometric errors and the performance of standard atmospheric correction procedures of Sentinel-3 OLCI

Cost: R430 500
Term: 2016 – 2018

Incorporating environmental fate models into risk assessment for pesticide registration in South Africa

CSIR; University of Pretoria

2524

Project aims:

- Evaluate current registration process used in South Africa and identify gaps in current risk assessment framework
- Evaluate international best practice risk assessment approaches in pesticide registration
- Evaluation of data requirements, data availability and data sensitivity of environmental fate and transport models used in risk assessment for pesticide registration
- Development of standardized exposure assessment scenarios for higher tier exposure assessments in SA risk assessment
- Propose an improved/revised risk assessment framework for pesticide registration in South Africa that adequately addresses fate and transport of pesticides in the environment

Cost: R1 000 000
Term: 2016 – 2019

Water resources protection: a review of the state-of-the-art and research and development needs for South Africa

Umvoto Africa (Pty) Ltd

2532

Project aims:

- Review current legislation and regulations to identify research gaps
- Review current governance to identify research gaps
- Identify knowledge gaps
- Research into the current land–water nexus

Cost: R400 000
Term: 2016–2017

Hybrid water supply systems and conjunctive use in the context of water-sensitive settlements: a case study of Sekhukhune District Municipality, Limpopo Province

Vaal University of Technology

2534

Project aims:

- Assess and determine the status of physical and hydrological attributes of surface and groundwater resources in this area
- Quantify and map the stormwater and rainwater harvesting potential of the area as an alternative water source
- Characterise the quality of rainwater and stormwater harvested
- Profile the existing and potential new water users with a view to determine their water use characteristics (vis-a-vis quality and quantity) so as to determine the probable alternative source(s) that is fit for the identified purpose
- Develop a framework/scheme for cascaded/stepped/staged development of alternative water sources for the area
- Develop a model for conjunctive use of surface and groundwater for SDM

Cost: R1 000 000
Term: 2016 – 2019

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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

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: EGreen 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 2016/17

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

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

WetResT (Centre for Wetland Research and Training); ARC Institute for Soil, Climate and Water; International Mire Conservation Group; Eon Consulting; Imperata Consulting; Wet-Earth Ecospecs; University of Groningen; Nancy Job; Sustento Development Services cc; Prime Africa Consultants cc

2346

Worldwide, peatlands cover approximately 3% of the earth's surface. The global carbon stored in peat is estimated to be in the order of 500 billion tons, approximately 30% of the world's soil carbon; as well as storing 10% of the world's freshwater. Although peatlands are not common in South Africa (less than 10% of SA wetlands are peatlands), some are unique. The Mfabeni Mire, for example, is 45 000 years old and is one of the oldest active peat-accumulating wetlands in the world. In South Africa, less is known about peatlands than other ecosystems such as forests, and so policy formulation and management decisions are not always grounded on a scientific knowledge base and may inadvertently lead to further destruction of these important ecosystems. Therefore, the first step in effective peatland conservation is to have accurate scientific baseline information in order to draft effective management guidelines and to define the socio-economic value of these ecosystems to society. Through this research project, 8 case-study peatlands in the different peat eco-regions have been characterized, classified and mapped to compile an inventory and to determine their conservation status. Based on these scientific baseline values the socio-economic value of peatlands in South Africa was established. The project not only supports the current wetland inventory of SANBI, DEA's obligations towards the Ramsar Convention and wetland rehabilitation initiatives, but also provides information on the credibility of conservation protocols in a regulatory environment where the value of ecosystems are forever competing in a losing battle with infrastructure

and social development initiatives. Therefore, the aim of this study was to evaluate the characteristics of peatlands and related processes; as well as their contribution to South African wetland ecosystem services.

Cost: R1 000 000
Term: 2014 – 2017

Programme 3:
Land-use and aquatic ecosystem management

Testing the preliminary guidelines for the determination of buffer zones for rivers, wetlands and estuaries

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

2463

This report is a refinement of the 'Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries' (Macfarlane et al., 2014). An opportunity was provided to test the preliminary guideline at a series of national training and development workshops. A key recommendation that came out of the workshops was the compilation of a technical manual and a separate practical guide. The technical manual highlights the complete process that was followed in the development of a guideline for the determination of buffer zones for rivers, wetlands and estuaries. It provides the concepts, background and technical aspects of the approach required for determining appropriate buffer zones. The separate practical guide provides users with the relevant information required to consistently determine aquatic impact buffer zones. In addition, the buffer zone tools were developed for determining desktop buffer zones. The technical manual therefore needs to be used in conjunction with the practical guide and the tools developed, namely: 'Practical guide for determining aquatic impact buffer zones for rivers, wetlands and estuaries', 'Desktop buffer zone tool'. It is hoped that this practical guide for the determination of aquatic impact buffers for rivers, wetlands and estuaries, along with the technical manual and the buffer zone tools, provide the tools required to meet the demand for a scientifically defensible approach to determining buffer zones.

Cost: R398 600
Term: 2015 – 2017

Programme 4:
Integrated environmental and drinking water quality

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; GroundTruth; University of KwaZulu-Natal (Pietermaritzburg); SANBI

2351

This study (conducted in KwaZulu-Natal and the Western Cape) has provided clear evidence to suggest that specific algal indicators defined by growth form and

division are sensitive and robust over a broad range of conditions. Not only do these indicators respond to flow and nutrient alteration, but seem to respond rapidly to change and thus are ideally suited as an early detection of ecological change in rivers. Therefore, these indicators are ideally suited to predicting the effects of flow alteration under different levels of enrichment as part of the ecological Reserve determination process. Furthermore, these indicators would provide a sound basis for establishing 'ecospecs' as part of the setting of Resource Quality Objectives for rivers affected by both quality and quantity changes. The greatest contribution to biomonitoring from this study was the testing of the rapid chl-*a* (algae) tool, called Bentho-Torch.

Cost: R1 223 574
Term: 2014 – 2017

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 2:
Ecosystem value-chain and markets

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

CSIR; Rhodes University
2341

The understanding of the value chains, markets and actual economic value of ecosystem services from aquatic ecosystems is still limited. Different studies have developed various approaches for determining the economic value of these benefits, as well as the associated natural capital. Most confirm that the value of aquatic ecosystems lies in the sustained net benefits derived from the many ecosystem services they supply; including various ecological functions, products for direct and indirect human consumption, energy, aesthetic and recreational benefits, and assimilative capacity of the residues of human activities. However, the geographic, cultural, and economic differences between countries or nations have resulted in different views which affect the market potential of ecosystem services from aquatic ecosystems. This study focused on identifying key ecosystem services, their forward linkages, understanding how to improve market access for such services, and to create or improve the value chains in the South African context. The research is intended to help identify more broadly the opportunities for improvements that benefit society. It is anticipated that the study will be useful to land use planners, the designers of infrastructure, and town planners. The study explored aquatic ecosystem services in South Africa within the context of a value chain assessment, with special focus on identify challenges and opportunities in the value chains of markets. A causal loop diagram (CLD) formed the basis for presenting and analysing the value chains of aquatic ecosystem services (AES). This model was the main product of this study;

however, it is still at an early stage and not yet ready for incorporation into policy and licensing. Further vigorous testing under different catchment scenarios (pollution pressure drivers) is required beyond the Baviaanskloof pilot study area. Tradable pollution permits (also called

cap-and-trade) – a market-based approach incentive to reduce pollution – was trialled in the Dwars River catchment, Western Cape, due to data demand for illustrations not available from Baviaanskloof. Tradable permits are based on the polluter-pays principle and aim to impose a cost on pollution, or generate a reward for pollution abatement. Filamentous algae treatment costs farmers more than R1.2 m/yr. Much verification and willingness of regulators will be required before this theory can be operationalized in South Africa, as it is administratively onerous.

Cost: R1 000 000
Term: 2014 – 2016

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
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
- 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

Cost: R2 700 000
Term: 2013–2015

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

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

Cost: R1 000 000
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
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

Cost: R1 000 000
Term: 2015 – 2018

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
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 geomorphological 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

Cost: R300 000
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
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

Cost: R1 700 000
Term: 2014 – 2018

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

SAEON Ndlovu Node

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

Cost: R882 000
Term: 2014 – 2017

Environmental water temperature guidelines: bridging the gap between research and implementation

Freshwater Research Centre; University of Venda; University of Cape Town

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

Cost: R1 500 000
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)

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

Cost: R1 500 000
Term: 2016–2019

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)

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

Cost: R990 000
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)

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

Cost: R1 774 700
Term: 2014 – 2017

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

AWARD

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

Cost: R2 000 000
Term: 2014 – 2017

Programme 4:
Integrated environmental and drinking water quality

Development of an immobilized receptor-based EDC detection kit

Stellenbosch University (Zoology)

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

Cost: R1 070 000
Term: 2013 – 2015

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

Cost: R2 000 000
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

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.

Cost: R1 796 800
Term: 2015 – 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

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.

Cost: R370 000
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

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

Cost: R1 432 180
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

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

Cost: R445 320
Term: 2013–2016

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

Stellenbosch University

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 E*ucalyptus* and *Acacia* mearnsii trees of different sizes growing at different stem densities in riparian sites from two different longitudinal zones

Cost: R1 500 000
Term: 2014–2017

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

GroundTruth cc

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

Cost: R2 500 000
Term: 2014–2019

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

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

Cost: R1 443 200
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

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

Cost: R500 000
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

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

Cost: R1 500 000
Term: 2015 – 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)

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

Cost: R2 907 000
Term: 2013 – 2018

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

Prime Africa cc
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

Cost: R2 000 000
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)
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

Cost: R5 000 000
Term: 2014 – 2020

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

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

Cost: R2 000 000
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

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

Cost: R500 000
Term: 2016 – 2018

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)
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

Cost: R1 000 000
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)
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

Cost: R1 333 000
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
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

Cost: R2 000 000
Term: 2015 – 2018

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

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

Cost: R600 000
Term: 2015 – 2017

Pharmaceuticals from South African aquatic plants

University of Pretoria; Mothong Heritage; Walter Sisulu University

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

Cost: R2 358 960
Term: 2016 – 2020

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

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

Cost: R1 500 000
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)

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

Cost: R500 000
Term: 2013 – 2016

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

University of the Witwatersrand (Chemistry)
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 palaeo-environmental 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

Cost: R849 500
Term: 2014 – 2017

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

Freshwater Research Centre
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

Cost: R1 860 100
Term: 2014 – 2017

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

Nelson Mandela Metropolitan University

2348

Project aims:

- Determine the level of biogeochemical cycling generated by primary producers (e.g. micro- and macro-algae) 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

Cost: R1 500 000
Term: 2014 – 2017

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)

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 SO2. Results from the model will be verified with actual data (dry and wet acid deposition) from other sources (e.g., Eskom and Josipovic data).

Cost: R700 000
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)

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

Cost: R1 200 000
Term: 2015 – 2017

THRUST 1: ECOSYSTEM PROCESSES

Programme 1:
River, wetland, groundwater and dam processes

Assessment of carbon storage in wetlands

Eon Consulting; WetResT (Centre for Wetland Research and Training); University of Pretoria

2542

Project aims:

- Assess, through a review of international and national literature, the effectiveness of wetlands to store carbon
- Assess, through field studies, the amounts of carbon stored in the various hydrogeomorphic wetland types
- Assess the flux of carbon in the wetlands
- Assess the value of using carbon storage as an indicator of wetland functionality and health
- Assess the value of carbon stored by wetlands and neighbouring ecosystems in terms of the UN-REDD+ programme

Cost: R880 000
Term: 2016 – 2018

Programme 2:
Estuarine, coastal and marine processes

The development of a Bayesian model of the ecosystem and mouth dynamics for temporary open/closed estuaries (TOCEs)

University of Zululand; Hydrological Research & Training Specialists

2541

Project aims:

- To understand and model the evolving relationship between fluvial and marine conditions/states (based on surrogate variables) that control the estuarine vegetation and mouth dynamics using a Bayesian statistical approach based on derived data and information from the Mlalazi catchment and estuary
- To model the hydrology and hydrodynamics of the Mlalazi catchment and estuary to provide the daily/sub-daily flows and depths at the mouth to provide the variables for the development of the Bayesian models of the vegetation and mouth dynamics
- To describe the present and historical vegetation patterns within the Mlalazi functional estuarine zone (including that in the beach region of the mouth) and describe the drivers that have caused these patterns

to provide the variables for the development of the Bayesian models of the vegetation
- To assist with the resurrection of the HRU as a sustainable Research Unit at the University of Zululand to promote advanced multidisciplinary research in aquatic coastal systems; this will be done by using the Mlalazi catchment, estuary and estuary mouth studies as a catchment-to-coast systems approach to support academic studies at postgraduate level

Cost: R1 000 000
Term: 2016 – 2019

Programme 4:
Surface and groundwater interactions

Development and application of passive samplers for determining the fate of toxic metals in wetlands polluted by mining activities

University of the Witwatersrand; Masaryk University
2551

Project aims:
- To develop a modified DGT derivative passive sampler for the evaluation of the fate of toxic heavy metals in wetlands
- To develop a modified DGT derivative passive sampler based on a polymer inclusion membrane for the evaluation of the fate of toxic heavy metals in wetlands
- To optimize a modified DGT derivative passive sampler for the evaluation of the fate of toxic heavy metals in wetlands
- To optimize a modified DGT derivative passive sampler based on a polymer inclusion membrane for the evaluation of the fate of toxic heavy metals in wetlands
- To apply the developed passive samplers for the evaluation of the fate of toxic heavy metals in wetlands
- To compare the performance of the developed passive samplers with commercial DGT

Cost: R760 000
Term: 2016 – 2019

THRUST 2:
ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1:
Ecological Reserve

Refinement of the Revised Desktop Reserve Model

Rivers for Africa; eFlows Consulting (Pty) Ltd; Rhodes University; Clean Stream Biological Services cc; Streamflow Solutions cc; MacKenzie Ecological and Development Services

2539

Overall aim: To provide an updated version of the RDRM model that can estimate EWRs at a desktop level, as well as be used to facilitate the links between hydrology, hydraulics and ecology within more detailed EWR assessments:

- To use select riparian vegetation information generated during the PES and EI-ES study (DWS/WRC), as well as SANBI spatial data, to compile a list of obligate species/guilds and their flooding requirements for direct use in the desktop model
- To develop the flood component sub-model based on generic rules linked to river type and hydraulics; this component must cater first and foremost for desktop use and must also include the opportunity to include specific determined floods identified during more detailed EWR assessments
- To use the fish and possibly invertebrate information generated during the PES and EI-ES study (DWS/WRC) to compile a list of species and taxa with sensitivities and weights attached to this for direct and automated use in the desktop model
- To revise the ecological sub-model and undertake the required testing which could not be done during the design of the model; the aim is to result in a more user-friendly subcomponent which is explicit in terms of the ecological link
- To ensure that all relevant stakeholders are aware of the revised model and the changes that have been made

Cost: R1 578 947
Term: 2016 – 2018

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

The development of a refined procedure for determining wetland RQOs, and the development of a wetland RQO implementation manual

Institute of Natural Resources NPC; University of KwaZulu-Natal (Pietermaritzburg); Wetland Consulting Services (Pty) Ltd

2547

Project aims:

- Develop a refined procedure for determining wetland RQOs
- Develop a wetland RQO implementation manual that provides a step-by-step approach to implementing wetland RQOs

Cost: R1 000 000
Term: 2016 – 2019

Atmospheric deposition impact assessment
EScience Associates (Pty) Ltd; North-West University (Potchefstroom); University of the Witwatersrand
2550

Project aims:

- Prepare the necessary historical and projected deposition scenarios
- Evaluate the adequacy of existing hydro-salinity models and make necessary improvements
- Set up the hydro-salinity model for the Vaal Dam catchment
- Calibrate the model for the main sub-catchments upstream of Vaal Dam
- Simulate historical and projected catchment runoff salinity and the status of Vaal Dam
- Estimate the economic impact

Cost: R900 000
Term: 2016–2018

Programme 4:
Integrated environmental and drinking water quality

Investigation of large-scale drivers of seasonal fluctuation on water chemistry and toxicant levels in the Flag Boshielo System
University of Limpopo
2544

Project aims:

- Explore seasonal fluctuations in selected water quality parameters at Flag Boshielo Dam during drought and flood cycles (if possible within the duration of the project)
- Evaluate seasonal fluctuation in the metal concentration in fish muscle at Flag Boshielo Dam
- Investigate the factors influencing the concentration of metals in fish muscle tissue at Flag Boshielo Dam by distance-based linear modelling of the environmental data
- Investigate whether crocodile deaths in the Kruger National Park can be linked to the quality of the water entering the park
- Propose management actions to improve the ecosystem health of Flag Boshielo Dam

Cost: R1 000 000
Term: 2016–2019

Programme 5:
Ecosystem risks and disaster management

Enabling more responsive policy and decision-making in relation to wetlands through improving the quality of spatial wetland data in South Africa

SANBI; Department of Environmental Affairs; University of KwaZulu-Natal (Pietermaritzburg); Nick Rivers-Moore; CSIR; Department of Water and Sanitation

2546

Project aims:

- Assess the accuracy of the current National Wetland Map and improve the quality of spatial data on wetland extent across the country
- Investigate the impacts of scale and regional environmental patterns on predictor variables informing probabilistic models of wetland occurrence, type and condition

Cost: R1 500 000
Term: 2016–2019

THRUST 4:
SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 4:
Green economy and sustainable (green) innovations

Insurance value of ecosystems: streamlining nature-based mitigation solutions to drought/floods in business

Institute of Natural Resources NPC; EconoLogic; Urban Earth (Pty) Ltd

2611

Project aims:

- To assess evidence of nature-based solutions in drought and flood mitigation
- To make evidence more intelligible to, and coherent for, business to incorporate into decision-making
- Recommend further research required to promote business's role in embracing nature
- To secure the insurance industry as a key research partner going forward

Cost: R200 000
Term: 2016 – 2017

Inland water related tourism in South Africa by 2030 in the light of global change

Institute of Natural Resources NPC; University of Limpopo; University of Venda

2620

Project aims:

- Undertake a baseline assessment that provides a sound understanding of the links between tourism and natural capital with a focus on inland water

resources

- Develop and apply models to understand and quantify global change risks, with a focus on water pollution, and mitigation measures to sustain inland water ecosystems and tourism
- Demonstrate how eco-tourism can benefit SMMEs in marginalised communities and generate a flow of economic and job creation benefits, using two pilot sites as examples
- Empower the pilot-site community to understand the sustainable development opportunities associated with healthy ecological infrastructure that supports inland water resource tourism
- Identify policy gaps and mitigation measures necessary to support sustainable tourism
- Generate recommendations for additional research required to promote environmental conservation through eco-tourism within the green economy context

Cost: R2 000 000
Term: 2016–2020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 3: Ecological thresholds

Establishing remote-sensing toolkits for monitoring freshwater ecosystems under global change

CSIR; University of Fort Hare; University of KwaZulu-Natal (Pietermaritzburg); University of the Free State; Freshwater Research Centre; Nancy Job; Wet-Earth Ecospecs

2545

Project aims:

- Determine the capability of the new space-borne sensors to separate wetland vegetation (communities or species) from upland vegetation (structural assessment)
- Assess the capability of SAR technology to detect the temporal dynamics of vegetation structure and wetland inundation
- Investigate whether EO tools can detect the seasonal or annual variation of freshwater ecosystems (reporting variation in structure, function and condition indices)
- Evaluate the capability of earth observation tools for the inventory and monitoring of freshwater ecosystems under global change as part of the national programmes such as the National Wetland Monitoring Programme

Cost: R2 620 000
Term: 2016 – 2020

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KSA 3: WATER USE & 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.

RESEARCH PORTFOLIO FOR 2016/17

COMPLETED PROJECTS

THRUST 1:
WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2:
Institutional and management issues – Water services

Assisting municipalities to determine the most appropriate indicator for funding allocations toward operations and maintenance
PDG
1121

The poor state of operations and maintenance of infrastructure in South Africa, not only in water services but across all sectors, is widely bemoaned. One of the overall findings of the CIDB and CSIR report was that few municipalities put enough of their budgets aside for infrastructure maintenance. Within this context, assisting municipalities to determine what level of funding they should allocate to maintenance is of vital importance and it is for this reason that the WRC commissioned this study. The exploratory methodology was based largely on a review of the literature, interviews with municipalities and other stakeholders, and some desktop analysis. Within this scope one can only draw tentative conclusions and make suggestions as to where further work is necessary.

Key conclusions emanating from the study are as follows:

- There remains significant confusion about definitions and terminology in the maintenance space, and more work needs to be done to ensure consistent and clear definitions. The alignment between CIDMS and mSCOA has been a good start here.
- Further clarity on what expenditure items should be considered as 'maintenance' is needed in order to ensure that reported expenditures on maintenance are referring to the same thing. mSCOA alone is unlikely to address this as municipalities will need guidance on which entries under the 'Item' segment should be recorded as maintenance under the 'Project' segment.
- The MFMA Circular 71 benchmark of 8% of the carrying value of PPE and investment property is a significant improvement on benchmarks based on the percentage of the municipal budget but it does not have a theoretically sound basis. It may be adequate as an indicator for high level monitoring by National Treasury but should not be used by municipalities themselves in determining whether they are making adequate allocations to maintenance. In interpreting

performance against this benchmark, National Treasury should bear in mind that it overstates maintenance needs in water and sanitation systems that are new but understates it in systems that are older. It will also be more or less accurate depending on the composition of the water and sanitation assets.

- Ultimately, the only way to assist municipalities to make adequate financial allocations to maintenance is to support them in progressively implementing sound infrastructure asset management and life cycle costing.

Cost: R237 318
Term: 2016 – 2017

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

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

2283

Local government institutions, especially municipalities, are currently looking at how they can address the impacts of climate change as part of their business process. However, there is very limited guidance regarding how this can be achieved and, even less so, guidance that is directly linked to their business, location, existing infrastructure, resources and other unique factors. In this study, a water sector climate change adaptation guide was developed. The guide deals with the selection of relevant water sector adaptation technologies and approaches for specific climate change impacts over the short, medium and long term. Specific objectives for this study include the following:

- To investigate if all or just some municipalities will need to adapt to climate change
- To develop a set of criteria to classify adaptation technologies and approaches
- To identify appropriate adaptation technologies and/or approaches to climate change at local government, community and/or household level
- To map the adaptation technologies for near-, medium- and long-term planning while taking into account the types of municipalities – rural, urban and metro
- To ascertain the institutional and capacity requirements of local government to roll out a climate change adaptation strategy
- To define practical implementation steps and planning horizons that will be required
- To provide a review and way forward for current research that could provide future solutions and address the gaps in the sector to meet climate change needs

Cost: R1 500 000
Term: 2013–2016

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; University of KwaZulu-Natal (Westville); Rand Water

2361

About 53% of waterworks in the sample set were not complying with legislation and some of these waterworks were operated by water utilities that have the capacity and resources to investigate alternative methods of water treatment residue (WTR) reuse and disposal. This suggests that current legislation for WTR management is too stringent and those that are complying are doing so at a much higher cost. Dialogue and co-operation through focused meetings and workshops between the water sector and the Department of Environmental Affairs (DEA) and other relevant government departments should be intensified to ensure stakeholder buy-in to an environmentally and financially sustainable solution to WTR management. A concerted effort should be made by water practitioners to engage with the DEA and provide the necessary technical input to assist the legislators and regulators with the creation of appropriate legislation for WTR management, especially with regard to challenges due to the blanket classification of WTR with other hazardous wastes. The fact that most of the contaminants found in the WTR emanate from the raw water indicates that the blanket classification of WTR as hazardous should be re-evaluated and input should be gathered from both regulators and water practitioners. This will reduce the cost of analysis and ensure adherence to relevant regulations, including measurable environmental compliance.

Cost: R1 000 000
Term: 2014 – 2016

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

University of the Western Cape; University of Fort Hare

2364

Emerging micropollutants such as bisphenol-A and 2-nitrophenol present a great threat in drinking and wastewater due to their adverse effects. These contaminants are also poorly understood, not easily biodegradable, unregulated and have become a huge public health issue as they have been detected in different water sources at nanogram per litre to microgram per litre concentrations. The aim of this study was to investigate the application of combined synthesized Ag-immobilized or plasmon-enhanced TiO_2 composites and dielectric barrier discharge (DBD) reactor for the degradation of

these micropollutants. The results obtained indicated that the removal efficiency of BPA and 2-NP by the DBD alone at 80 minutes of reaction time was 67.22% and 56.8%, respectively. The combined DBD with 2.4% Ag-doped TiO_2 nanocomposites achieved 89% and 81% removal efficiency for BPA and 2-NP, respectively, as compared to 67.22% and 56.8% obtained while using the DBD system alone. This shows that the incorporation of supported Ag-doped TiO_2 photocatalysts improved BPA or 2-NP removal efficiency by 21.8% and 24.2%, respectively, compared to DBD alone. The supported Ag-loaded carbon-doped catalyst can be recycled due to maintenance of its crystalline nature and pure anatase polymorph after four repeated applications. The results obtained for the change of TOC were rather low due to formation of the intermediates that were quite refractory to further mineralization. The major shortcoming of the supported Ag-doped TiO_2 photocatalyst was the leaching of metallic species such as Fe, Cr and Ni from the stainless-steel mesh support.

Cost: R787 400
Term: 2014 – 2017

Evaluation and selection of an appropriate automatic coagulant dose control system for conventional water treatment plants

Umgeni Water; University of KwaZulu-Natal (Howard College); Rand Water

2396

When used in the right environment, the SCD technique is the most appropriate automatic dose control system that is currently available in South Africa. The mathematical model based on historical water treatment plant data may be applied for an automatic coagulant provided great care is taken in the quality control of analytical measurements that constitute the historical datasets. The mathematical model, once established, may be applicable to water treatment plant optimisation in addition to automatic coagulant dose control.

Cost: R450 000
Term: 2014 – 2016

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; Technical University of Berlin

2367

Overloading of wastewater treatment systems, along with the inadequate provision of sewerage in many rural areas, can result in release from water treatment facilities of very poor quality surface waters that contain high concentrations of emerging organic contaminants. These xenobiotics include pharmaceuticals, and frequently also cyanotoxins where polishing ponds precede release. The released water typically also contains high levels of nutrients. The reliance on raw water for household use, although diminishing, is still high, and the use

of raw water that may contain xenobiotics or natural toxins, for agriculture, aquaculture and recreation, also poses certain risks. In addition to these problems, the increased costs required for potable water production from contaminated raw waters is significant, and often beyond the capabilities of smaller water purification plants. The added ecotoxicological concerns and the emergence of antibiotic resistance in environmental samples, with the implications for emerging resistance in pathogens, indicates an urgent need to address these contaminants. A low-technology, low-maintenance and low-cost solution is therefore required for treatment of such contaminated raw waters, either at source or prior to abstraction. The system should also be suitable for purification of an impoundment in situ. The report proposes a biological system based on the 'green liver' systems successfully implemented in China and Brazil. This system, which follows the same principles as the ecological infrastructure, was developed and tested in the laboratory, using selected macrophytes. A series of tests and combinations of plant species and the targeted contaminants, including nevirapene, ampicillin and others, were used in the experiment. The testing chambers also allowed different concentrations and flow rates to be tested. Plants were tested for biotransformation, bioaccumulation and depuration. Ultimately, the best sequence of macrophytes in removing specific contaminants was established in a model called the High Throughput Sequential Phytoremediation System (HTSPS). This innovative model has proven effective in purifying emerging contaminants at laboratory scale; it is now ready to be piloted in the field.

Cost: R450 000
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; Sustainability Institute
2368

In order to provide clean and safe drinking water to communities collecting rainwater, the development of effective water treatment methods is required. Pasteurization has been recommended as a possible treatment method, i.e., the closed-coupled solar pasteurization treatment system utilised in WRC Project K5/2124/3. However, it is well known that pasteurization may not improve the chemical quality of harvested rainwater and for this reason the roofing materials utilised as the catchment areas for rainwater harvesting systems need to have no primary influence on the rainwater quality. Social perceptions of implementing a pilot domestic rainwater harvesting (DRWH) multi-tank station in the Enkanini informal settlement as an alternative water supply were investigated. Approximately 61% of the respondents were familiar with the concept of rainwater harvesting and while 32% were unfamiliar with the concept, 67% of the respondents indicated that they would utilise harvested rainwater for their daily water needs. Among the respondents, 77% indicated that they would utilise the rainwater for cleaning the house and bathing, 65% would utilise the rainwater for cooking,

while 46% will use it for potable or drinking purposes. Additionally, 67% perceived rainwater to be clean and safe to drink. This revealed a general lack of awareness of the potential health risks of consuming untreated rainwater. Moreover, most of the respondents (68) confirmed that they would use the rainwater instead of municipal water should the tanks be close to their homes. The effect of environmental factors on locally produced and utilised shack dwelling building materials and on the chemical and microbial quality of the harvested rainwater was investigated. The results obtained indicated that the chemical quality of the rainwater varied based on the roofing material utilised to construct the catchment system. The type of roofing material is therefore an important consideration when designing a rainwater harvesting system. Future research should thus focus on monitoring the effect of commercially available roof coating materials on the quality of harvested rainwater. During the monitoring period, it was determined that the small- and large-scale (water collected directly from the solar manifold) solar pasteurization systems were able to treat harvested rainwater to within drinking water standards at 71°C and above, however, cations (Zn and As) were detected at levels exceeding the recommended drinking water guidelines and therefore a filtration mechanism for the removal of chemical contaminants may need to be included in the design of the system.

Cost: R900 000
Term: 2014 – 2017

Programme 3:
Drinking water quality

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

Chris Swartz Water Utilisation Engineers; CSIR; University of the Western Cape

2369

Wastewater reuse acts as a possible exposure pathway to a high number of emerging contaminants and their metabolites. A portfolio of treatment options is available to mitigate water quality issues in reclaimed water. However, most municipal wastewater treatment plants are not specifically designed to deal with the emerging contaminants found in wastewater. Many of these compounds may pass through conventional wastewater treatment systems without removal and accumulate in potable water supplies. Thus, there is uncertainty over the magnitude of risk of human exposure to emerging contaminants of concern in wastewater treated for direct potable reuse. There is also a need to study the health-based targets, water quality monitoring and the dynamics and requirements for social acceptance of direct potable reuse in order to ensure successful implementation and long-term sustainability of such projects. The possible presence of emerging contaminants in reclaimed municipal wastewater is of critical concern because of potential adverse impacts to human health. Specific health effect 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 against similar risk of using conventional water supplies, and (iii) the need for extensive toxicity programmes. This project was undertaken to identify the 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 for removal of these chemicals, and risks for potable water reuse. It included the development of guidelines for implementation of barriers, monitoring programmes and assessment programmes to eliminate or minimise these risks.

Cost: R1 500 000
Term 2014 – 2016

Programme 4:
Water distribution and distribution systems

Interpretation of logging results as a water distribution system management tool
WRP Consulting Engineers (Pty) Ltd
1124

Operational problems in municipal water networks can in some cases be difficult and time consuming to resolve. Such problems can include, but are not limited to, areas with unexplained high or low water pressure, areas with erratic/fluctuating pressures, reservoirs that either run dry or overflow or unexplained connections between two apparent discrete pressure zones. Few municipalities are equipped to resolve such problems quickly and efficiently. In many municipalities, the problem is also exacerbated by insufficient personnel and budgets for operation and maintenance. Operational staff should be equipped to identify and resolve water-related operational problems quickly and efficiently. This will assist in improving customer satisfaction, prolong infrastructure life and reduce water wastage. This report provides a guideline for municipalities to identify and resolve a number of different operational problems (in water reticulation systems) through logging of pressures and flows and the interpretation of those logging results.

Cost: R300 000
Term: 2016 – 2017

The effect of age on the friction of large diameter potable water cement mortar lined pipelines
University of KwaZulu-Natal (Howard College); Umgeni Water
2372

The change in roughness of water distribution pipelines is important and influenced by many factors such as tuberculation, sedimentation, biofilm growth, etc. These factors depend on a number of parameters such as water quality, flow characteristics, pipe materials and age, and temperature. Improved quantification and identification of these factors requires further investigation, reviewing the available literature, conducting experimental investigations, performing field investigations, and

developing models/software that will assist designers in evaluating a pipeline system over its full life cycle. Previous studies have shown that biofilm, aggregates of cells of polymeric substances which grow on the pipe wall, affects the friction factor as well as lifespan of pipe networks. The rate of bacterial attachment, growth and death are dependent on chlorine and chloramines present, water quality, pipe materials and lining, flow characteristics and temperature. The study focused on studying biofilm processes, with various disinfectant concentrations, for polyvinyl chloride and cement mortar lined water distribution pipeline materials, and developing a mathematical relationship relating friction factor and other hydraulic parameters. This study demonstrates the relation between biomass/film growth and roughness or friction using shear stress profiles. Though the results suggest that biofilm formation is expected to be slowest in regions of high velocity, these results were obtained under laboratory conditions where a number of factors were controlled. A higher velocity producing higher stress may kill more mature biofilms, but it may not be easy to detach young, thin biofilms even by increasing the velocity.

Cost: R354 000
Term: 2014 – 2016

THRUST 3:
SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1:
Emerging treatment technologies – Preparing for the future

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

University of KwaZulu-Natal (Pietermaritzburg); eThekwini Municipality; Bremen Overseas Research and Development Agency

2220

The aim of this project was to generate information on recycling of nutrients from DEWATS technology and other human excreta–derived materials (HEDM) that will inform policymakers and town planners in the design of new social housing developments that include an agricultural component. The specific objectives were

- To identify suitable agricultural areas in terms of liquid loading capacity, soil and climatic variables
- To evaluate the effect of wastewater use on soils and crop production, including risks of microbial contamination
- To assess the quality of wastewater and its effects on the environment
- To generate information that could be used to develop protocols that integrate agriculture in social housing development schemes

These objectives were achieved through field, tunnel and laboratory activities that focused on the 'nutrient uptake' aspect, with some attempt at achieving nutrient balances and thus estimate of nutrient loss. The soil processes that govern the two most critical elements in human waste for both plant growth and possible environmental problems, namely nitrogen (N) and phosphorus (P), were the main focus. This involved their behaviour when applied in liquid (effluent) and solid (HEDM) form. Effluent application considered both the nutrient and water demands of the crops as opposed to the solid waste which concentrated on the former aspect. Other critical aspects of these materials examined were their pathogen content and their behaviour in soil as well as their acceptability for use by the target communities.

Cost: R1 880 000
Term: 2013 – 2016

Programme 2:
Application of appropriate technologies and tools

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

Prime Africa Consultants cc
2210

Wastewater treatment (WWT) services are one of the core business responsibilities of a municipality. Legislation in South Africa ensures access to water services, affordably and effectively, to all consumers, in an economical and sustainable manner. The approach for setting an effective wastewater treatment tariff is challenging because it requires coordination of activities across multiple municipal departments and the setting of an effective tariff requires a long-term perspective. Fundamentally, a wastewater tariff set by a municipality needs to cover all costs associated with the treatment of wastewater to an appropriate environmental standard. The barriers to the implementation of effective wastewater treatment charges by municipalities were investigated through consultation with key stakeholders from the public and private sector through surveys, a national workshop and interviews. The main barriers identified included cost accounting, ring-fencing, asset management, human resources and knowledge of the client base. At some municipalities, the costs associated with WWT service provision are not separated from other municipal expenses and revenue generated from WWT services provisioned are not entirely reallocated to fund WWT capital and operating expenditure. Many municipalities found it difficult to account for assets and make provision for maintenance and replacement. Furthermore, insufficient information on the client base makes the mandate of differentiating between types of water service users to ensure social equity difficult. An overarching barrier to these goals is the insufficient human resource capacity to address these issues.

Cost: R1 243 500
Term: 2013-2016

The contribution of WRC research to sustainable municipal wastewater and sanitation services

Sarah Slabbert Associates

2476

This study investigated the knowledge needs of municipal officials as a way of providing the WRC with insight into how their research products rate in terms of awareness, uptake and impact within the municipal environment and hence the contribution that these products make to sustainable wastewater and sanitation services. This was achieved through an assessment of the following;

- Uptake and impact of the WRC research products in wastewater and sanitation services
- Factors shaping use of research-based knowledge in the municipal environment; and success stories and existing opportunities
- The main study findings suggest the need to address, inter alia, the following;
- Promotion and fostering of partnerships amongst key stakeholders within the wastewater research sector
- Creation of a culture of knowledge sharing and mentorship within municipalities
- Development of more effective dissemination mechanisms that promote better uptake of current knowledge products, particularly by rural municipalities
- Creation of forums/platforms that bring the municipal community together for active interaction in addressing their daily operational challenges
- Driving awareness of the WRC and its knowledge products within municipal environments through a robust marketing and communication drive

Cost: R750 000
Term: 2015 – 2016

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

2306

This research project fell under the umbrella of the larger programme known as the Sanitation Research Fund for Africa (SRFA), which seeks to build capacity and stimulate innovation in faecal sludge management on the African continent. The purpose of this study was to evaluate the potential for the beneficiation of faecal sludge from ventilated improved pit latrines (VIPs) through treatment in a hybridised anaerobic digestion and pasteurisation (ADAPT) system with biogas, generated from the anaerobic process, used for heat sterilisation purposes. VIP toilets in the Eastern Cape Province were emptied and the faecal sludge treated in a laboratory-scale reactor. Early laboratory results indicated that the faecal sludge had undergone a degree of stabilisation with the biogas generated from the digestion process not sufficient to sustain the pasteurisation process. In order to increase biogas output, the co-digestion of faecal sludge with other organic feeds was evaluated. A series of bench-top experiments were performed using Schott bottles as mini anaerobic digesters to determine the most suitable organic

co-feed to improve biogas output. Algae were found to be a most useful co-feed, but for practical purposes, anaerobic digester sludge from a wastewater treatment works was used as this was easily accessible. Generation of a combustible biogas was demonstrated in this study, but the greatest difficulty reported was preventing biogas leakages and storing captured biogas. Nevertheless, the potential for generating biogas for pasteurisation was demonstrated, although augmentation with liquid petroleum gas is a likely prospect in a commercial process. Pasteurisation efficiency can be enhanced by insulating the sides of the pasteurisation vessel. Further design work needs to be carried out to reach the optimal insulation of the vessel. Pasteurisation was shown to be effective in eliminating the threat of selected bacterial pathogens; however, the effectivity against helminths is moot. With one exception, no helminths were detected in the faecal sludge samples. A metagenomic study was carried out over seven pits where different depths in the latrine pit were sampled in order to better understand the biological processes that occur in latrine pits. The resolution of the study was poor due to limitations of the reference database, although bacteria typically associated with anaerobic digestion were detected in the samples. However, some bacterial families containing noted pathogens were also identified in sludge samples and indicate consequences for the health of sanitary workers and the surrounding community. Future studies should focus on determining whether these putative pathogens are indeed present in pit latrines.

Cost: R1 180 000
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)

2307

This project fell under a larger programme known as the Sanitation Research Fund for Africa (SRFA) funded by the WRC and the Bill & Melinda Gates Foundation (BMGF). The goals of this project within the SRFA programme were to improve research capacity on faecal sludge management at the North-West University (NWU Potchefstroom campus) and Tlokwe Local Municipality, with emphasis on the co-digestion of organic waste streams with faecal sludge. The specific aim of the project was to establish the feasibility of co-digestion of faecal sludge and other organic sources with municipal sludges at Tlokwe wastewater treatment plant. The research indicated that the co-digestion of 'fresh' faecal sludge (top layer sludge) with sewage sludge will neither significantly improve nor impede the biogas or methane yield, making the co-digestion of these substrates an alternative disposal route for faecal sludge. Further, it showed the importance of seeding in the overall digestion process. For the co-digestion disposal route to be effective, an appropriate containment, transport and collection system for faecal sludge has to be implemented to provide relatively fresh sludge.

Cost: R1 050 000
Term: 2013 – 2017

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

Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Howard College); University of Venda; North-West University (Mafikeng); South African Water and Sanitation Association

2379

This study was initiated to better understand three common issues that were reported in previous fieldwork studies commissioned by the WRC: realities of open defaecation in relation to basic sanitation infrastructure provision, the practice of geophagia (consumption of soil) and helminthiasis (infection with intestinal parasitic worms). This study sought to understand the beliefs, knowledge, attitudes, practices and consequences associated with these three phenomena and explore the role which open defaecation and geophagia may play in the transmission of helminthic infections and diarrhoeal diseases.

Cost: R750 000
Term: 2014 – 2016

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

2478

The study used City of Johannesburg's full-scale CHP installation as a case study to:

- Provide a practical guideline for the design and operation of a sludge treatment plant, with enhanced CHP generation
- Identify and quantify the opportunities to replicate this approach across the South African industry, at municipal WWTWs which already incorporate anaerobic digestion

In this regard, design principles of the various process units that are involved in sludge processing (sludge thickening, cell lysis, anaerobic digestion, and biogas to electrical energy (CHP), struvite (MAP) recovery, solar drying beds, sludge composting and offsetting of the final biosolids product) were identified, while operational data were collected from the Johannesburg Northern plant, and Olifantsvlei WWTW, for each process step involved in producing, thickening, conditioning, treating and digesting sludge related to biogas production for the CHP system. Performance was analysed for each process unit by considering the sludge quality input to the process unit, the outflow from the unit and the expected design performance of each particular process unit. The hydraulic retention in the anaerobic digesters was identified as an important operating parameter with regard to biogas production and a direct correlation between reduced hydraulic retention and reduced electrical power made. In addition, the lower temperature has a negative knock-on effect on digester efficiency and biogas production and this result in reduced efficiencies. Mapping of anaerobic digestion in

SA indicated that 46 water services authorities (WSAs) (out of 152) have approximately 420 anaerobic digesters, which are spread across 108 WWTWs (out of 824) across 9 provinces, with a corresponding design volume of 1 367 ML. A tool designed to calculate the potential electrical energy at each of the 108 WWTWs with anaerobic digesters estimated an achievement of a total biogas production of 282 671 m^3/day, translating to electrical energy of 657 765 kWh/day, with a monetary value of R 144 million/annum at 60 cents/kWh of electricity. The study further offered a model to give practical guidance on the minimum requirements to economically and sustainably develop biogas to energy at a given plant. For the purposes of this study, the 'minimum feasibility requirement' is defined as a CHP project with an assumed lifespan of 15 years that will pay back the investment including financing cost over the project life cycle of 15 years. In this regard, any loading or condition better than the model curve will result in the generation of a positive cash flow over the project life cycle.

Cost: R550 000
Term: 2015 – 2016

Programme 5:
Sanitation technology and innovations

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

University of Cape Town
2380

In this project, the concept of the wastewater biorefinery (WWBR) was investigated, i.e., the integrated processing of a wastewater stream or streams to generate products of value, including 'clean' water, and remediate the effluent simultaneously. The focus has been on both developing and testing this concept as well as evaluating its applicability to and potential in the South African context. In this regard, review of relevant research was done internationally and nationally, presenting extensive literature reviews with regards to the different aspects of WWBR, addressing both the global and local context. This included a review on the wastewater streams available in South Africa, thereby examining some potential products as well as the bioreactors required to produce them. To contextualise the findings in an integrated system, a generic flowsheet and mass balance model was developed and used to explore the features of the integrated biorefinery to assess a few conceptual case studies. The need to integrate multiple unit operations to ensure compliant water as well as produce a bioproduct or bioproducts has been highlighted as key. A model of these integrated unit operations that generates material inventories across the system was developed. This can be used to help to evaluate possible scenarios in an integrated context through the use of a generic flowsheet and mass balances. Consistent data on wastewater has been observed to be lacking. This is the clearest need emerging from this study in terms of assessing the national position, both for the development of the WWBR and for conventional environmental management. There is a need for specification of the approach to data collection, including the manner of measurement, frequency of recording and responsibility

for reporting and collection. The data required, and its form, must be specified. This also includes the development of appropriate instrumentation. This study concluded that the economic considerations around specific WWBR cases cannot be considered in a generic manner, yielding a universal solution, but is dependent on regional locality, product market needs, logistics and other factors at play. A lack of sufficient data to inform economic decisions is an expected concern at this stage. In terms of further studies, detailed techno-economic studies coupled with integrated pilot studies on a case study basis to provide more insight have been recommended.

Cost: R1 200 000
Term: 2014 – 2016

THRUST 4:
SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

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

University of Pretoria; Tshwane University of Technology
2384

The traditional sorghum beer industry is a beverage industry, and water, sorghum, and energy are essential for its operation. This NATSURV outlines industrial operations, the degree to which resources are managed using a set of indicators per unit of production (e.g. specific water intake), best practices adopted or currently under implementation and, finally, provides recommendations that can improve resource utilisation. A key feature on the changes in this industry since the 1st edition (1989) is its decline, both in number of breweries and volume of beer produced per annum. The annual beer production has decreased about five-fold as the number of breweries and malting plants declined from 33 and 5 in 1989 to 4 and 1 in 2016, respectively. The average specific water intake and specific effluent volume per unit product have increased, possibly due to closure of bigger plants where the larger production volumes are accompanied by lower per unit water consumption due to economies of scale. The COD, TDS and SS values for the wastewaters showed a reduction compared to 1989. Both the annual water usage and effluent generated (total volumes) have decreased. Overall, with the ongoing process of improving the sorghum beer industry through modernization (e.g. automation of certain processes) and incorporation of best practices such as using cleaning-in-place (CIP), and adoption of stringent accounting systems for process resources, it is likely that the performance of water, energy and waste in this industry will improve considerably.

Cost: R700 000
Term: 2015 – 2016

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

Cape Peninsula University of Technology; Chris Swartz Water Utilisation Engineers

2404

Manufacturing and processing industries consume significant quantities of energy and water. In addition, unwanted liquid, solid and gaseous waste is generated along with the intended products. Novel, more sustainable methods are constantly being sought to reduce qualitative and quantitative industrial pollutant loads and re-use water and waste. This move is largely in response to a number of interrelated factors, including higher costs of waste disposal, more stringent legislative requirements, and increasing environmental awareness. Between 1986 and 2001, the WRC commissioned 16 national surveys (NATSURVs) of various agri and non-agri industries (malt brewing, poultry, red meat, edible oil (EO), sorghum malt and beer, dairy, sugar, metal finishing, soft drink, tanning and leather finishing, laundry, textile, oil and refining, power generating). This culminated in the publication of 16 separate NATSURV documents, one for each industry. One of these, entitled 'Water and wastewater management in the edible oil industry' (WRC TT-40-89) included information about specific and generic production processes, water usage, solid waste generation, and wastewater quality, quantity and treatment practices in SA EO industry. This new survey serves to update the content of the original document, highlighting the changes which have taken place in the industry over the past two and a half decades. The report includes information stemming from an audit of the industry from both a local and global perspective. Limited information about the local EO industry was obtained using combined desktop, site-visit, and laboratory-based approaches. In addition to water and wastewater management, the document includes a section on energy audits and adoption/non-adoption of sustainable procedures by the industry at large.

Cost: R750 000
Term: 2014 – 2016

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

Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology

2405

This National Survey (NATSURV) provides an overview of the laundry industry, its changes since the 1980s and its projected changes. It critically evaluates and documents the generic laundry processes in terms of current practice, best practice and cleaner production. We have determined 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. We also determined wastewater generation, typical pollutant loads (diurnal trends) and best practice technology adoption. The local electricity, water, and effluent prices and by-laws within which these industries function have been described and evaluated to judge if the trends and indicators are in line with water conservation demand

management and environmental imperatives. The NATSURV evaluates the specific industry water (including wastewater) management processes adopted and provides appropriate recommendations, and 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. Finally, we have provided recommendations on the best practice for this industry. The application of water-conservation techniques should enable commercial laundries to have specific water intake of 12–15 L/kg and 1.5–4.5 L/kg for washer-extractors and continuous batch washers, respectively. Water consumption must be accurately monitored and ultimately compared with theoretical, programmed water use. When the comparison reveals that more water is used than required, it will then be possible to start identifying causes. Economic and simple wastewater treatment processes should be reviewed and implemented first before considering more sophisticated options. Emphasis is placed on the control of pH and the removal of solids. The control of pH is essential since municipalities generally limit the wastewater they receive to a pH of 5–9. Failing to adhere to this range incurs a charge to the laundry. The highly alkaline wastewater generated by commercial laundries can be treated with an acidifying chemical. The only solids in laundry wastewater are colloidal, or tiny suspended particles. Colloidal solids will not settle out unaided so coagulation and flocculation chemicals can be added to assist in the sedimentation process. For a relatively small capital outlay for a settling tank and some chemical dosing equipment, a considerable improvement in the quality of the wastewater can be expected, with concurrent savings in municipal wastewater treatment charges. For further treatment of laundry wastewaters, perhaps for reuse of rinse water as well as wash water, more sophisticated treatments may be necessary. These processes are all capital intensive and would only be worth considering as a second stage after simple wastewater treatment and management measures had been implemented.

Cost: R700 000
Term: 2014 – 2016

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
2421

Twenty-nine paper and pulp mills are operational in South Africa. The bulk of production is performed by the five largest manufacturers, namely Kimberly-Clark, Mondi, Mpact, Sappi and Twinsaver Group. These companies operate 15 mills of which 8 are paper and pulp mills and the remaining 5 are paper mills. The study included 11 independent tissue manufacturers and 3 independent packaging material manufacturers in this sector. The big manufacturers, as well as the independent packaging material manufacturers, participated fully in the study. Raw water intake to the manufacturing process is usually derived from a water resource where the abstraction is authorised by the Department of Water and Sanitation, or from the local municipality. The specific water intake (SWI) for the 22

participating sites varied between 3.5 and 76.1 m^3/t. For the paper and pulp mills the SWI varied between 11.9 and 76.1 m^3/t and for paper mills between 3.5 and 38.8 m^3/t. This represented a marked decrease from the 1990 edition which reported 33–136 m^3/t for paper and pulp mills and 1–49 m^3/t for paper mills. Different volumes and quality of wastewater are produced during the manufacturing processes. Effluents are treated via a range of treatment technologies which include clarification, activated sludge, dissolved air floatation and belt presses. The treated effluents are discharged to the receiving environment or reused/recycled to the manufacturing process where technically feasible. The specific effluent volume (SEV) generated varied between 0.08 and 84.5 m^3/t. For paper and pulp mills the SEV varied between 10.5 and 84.5 m^3/t and for paper mills between 0.08 and 38.2 m^3/t. The variations between water intake and effluent generation are a function of a range of factors such as feed material used, technology selection, product produced and the age of the facility. A comparison of the 1st and 2nd edition (1990 vs. 2015) shows that:

- A larger sample of mills participated in the 2015 survey than in 1990
- Differentiation between integrated paper and pulp mills and non-integrated paper mills was added to the 2015 survey
- Average SWI decreased from 40.0 m^3/t to 25.2 m^3/t and the maximum SWI decreased from 136 to 76.1
- Average SEV decreased from 28.6 m^3/t to 22.8 m^3/t and the maximum SEV decreased from 103 to 84.5
- Average and maximum COD, conductivity and SS levels have decreased
-

The reduction in SWI and SEV is a reflection of actions taken by the industry to recover and re-use water, thereby reducing freshwater intake. This awareness was confirmed by the improvement in effluent treatment technologies and equipment at a number of the sites surveyed. The use of water footprinting and risk management were key considerations when undertaking facility expansion studies and selecting appropriate technologies. Increasing electricity costs and the damaging impact of load-shedding has also resulted in and increased energy awareness across the industry. The data indicate that the South African paper and pulp industry is performing on par or exceeding international standards. The generation of renewable energy from waste products is a consideration at larger sites and has already been incorporated at some of the plants. Specific energy consumption (SEC) ranges from 1.6 to 6.3 GJ/ADt, as Eskom electricity. Total SEC ranges for 3.7 to 11.3 GJ/ADt) which includes Eskom electricity, steam, renewable/recoverable energy, coal to steam and gas. The industry is extensively regulated through the application of national legislation (in particular water use authorisations), municipal trade-effluent bylaws, as well as national and international norms and standards such as ISO and SANS. The study shares perspectives by the industry and the regulatory authorities pertaining to the use of water and effluent targets and compliance with norms, standards and specifications.

Cost: R850 000
Term: 2014 – 2017

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

Water Group Holdings (Pty) Ltd; Prodomos Technologies (Pty) Ltd

2422

The purpose of the NATSURV 20 Study is to review the status of the South African iron and steel industry with specific focus on national production capacity, specific water intake and effluent volumes, specific energy consumption rates and best practices in the management of water and effluent. The study includes an evaluation of the most pertinent legislation that regulates the industry on national and local levels. Five companies operate iron and steel mills in South Africa. One of these companies declined to participate, with the other four providing information to different levels of completeness. Due to the severe economic pressure in this sector, one of the four companies went into business rescue procedures and another entered a round of retrenchments with the result that these two companies could not provide all requested information due to limited resource availability. Thus only a limited amount of data are available. Raw water intake to the manufacturing process is usually derived from a water resource where the abstraction is authorised by the Department of Water and Sanitation, or from the local municipality. The specific water intake (SWI) for the four sites for which data were received varied between 2.3 and 9.3 m^3/t. The specific effluent volume (SEV) generated varied between 0.9 and 3.6 m^3/t. Different volumes and quality of wastewater (effluent) are produced during the manufacturing processes. Effluents are treated via a range of treatment technologies which include clarification, activated sludge, dissolved air floatation and evaporation. The treated effluent is discharged to the receiving environment or reused/recycled to the manufacturing process where technically feasible. The variation between water intake and effluent generation is a function of a range of factors such as age of facility, technology selection and product produced. Depending on the product range, the concentration of various metals used on site are also monitored. Energy awareness has also grown in the industry, both as a result of increasing electricity costs as well as due to the detrimental effect of load-shedding. The study found that the industry is extensively regulated through national legislation (in particular water use authorisations), municipal trade-effluent bylaws, as well as national and international norms and standards such as ISO and SANS. The study shares perspectives by the industry and the regulator pertaining to the use of water and effluent targets and compliance with norms, standards and specifications. It is recommended that continuous improvement focusing on improved SWI and SEV target continue to be used in this industry; and that research continues to explore the energy and resource recovery potential associated with the industry.

Cost: R850 000
Term: 2014 – 2017

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

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; Atl-Hydro; University of Fort Hare; University of Johannesburg
2386

The textile industry is one of the most chemically intensive industries on earth, using more than 100 000 types of chemicals and the number-one polluter of potentially potable water internationally. The aim of this project was to assess the application of one of the emerging nanotechnologies for water treatment, namely, nanofiltration and nanophotocatalytic treatment of the nanofilter retentate. The objectives of this work were:

- To conduct a stream segregation scoping assessment and a cleaner production effluent audit for a proposed wastewater treatment process at the Falke Eurosocks
- To design, build and evaluate a pilot-scale rig for the treatment of textile effluent using pre-filtration, ultrafiltration and nanofiltration
- To develop synthesis strategies for production of controlled sized titanium dioxide nanophotocatalyst powders
- To develop and optimize technology to treat effluent using immobilised titanium dioxide nanoparticles under daylight in a trickle-bed reactor
- To evaluate the performance of the nanofiltration and photocatalysis of real textile effluent; this report presents results for the treatment of commercial textile effluents using nanofiltration and photocatalysis using nano-titanium dioxide

The stream segregation audit revealed that the installation of three-way valves into the existing piping systems can easily facilitate separation of waste streams for treatment and reuse. Boiler water and condensate can be treated and separated from the dye vat effluents. This will reduce the footprint of the final effluent treatment plant.

Several strategies were developed for the local production of nano-titanium dioxide powders for use in photocatalysis. Existing sol-gel methods were improved. Robust process conditions were established for the production of sub-10 nm particles using continuous hydrothermal synthesis to produce multi-polymorph anatase-rich nano-titanium dioxide. These results are very encouraging showing the possibilities for locally manufactured photocatalysts to be used in the treatment of textile effluents. Various methods of immobilising nano-titanium dioxide were evaluated. The industrial potential for the utilisation of the nano-titanium dioxide immobilisation techniques developed in this work is great since there is a nanofibre spinning company in Cape Town able to produce large mats that could be incorporated in a multistage thin film fixed bed photocatalytic reactor for upscaling of the process using artificial and/or natural sunlight. An ultrafiltration/ nanofiltration pilot effluent treatment plant was designed and installed at the factory. Under the current conditions, 50% of water could be recovered as the nanofiltration

permeate. The colour was successfully removed from the nanofiltration brine during treatment using standard conditions under which the sample was only treated for 90 minutes; if treatment time is increased, further removal of COD and TOC could be achieved. The inorganic ions can be recovered during a further treatment step.

Cost: R1 250 000
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
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.

Cost: R1 620 113
Term: 2013 – 2015

Revising the DWA guidelines on municipal tariffs for water services

Nelson Mandela Metropolitan University
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.

Cost: R1 600 000
Term: 2014 – 2017

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

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).

Cost: R800 000
Term: 2015 – 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
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
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.

Cost: R1 180 000
Term: 2013 – 2016

Loss aversion and water conservation

University of Cape Town
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.

Cost: R642 537
Term: 2014 – 2017

Review of urban sanitation in South Africa – challenges and constraints

Palmer Development Group
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.

Cost: R594 839
Term: 2015 – 2017

Developing innovative approaches to national allocations and transfers to local government

Palmer Development Group
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.

Cost: R652 800
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
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.

Cost: R500 000
Term: 2015 – 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
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.

Cost: R1 890 000
Term: 2014 – 2017

Programme 4:
Programme 4: Regulation of water services

Extending performance monitoring and analysis in South Africa

Nelson Mandela Metropolitan University
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.

Cost: R850 000
Term: 2014 – 2016

THRUST 2:
WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1:
Drinking water treatment technology

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

University of Venda

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.

Cost: R690 2000
Term: 2014 – 2017

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

University of Johannesburg

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 fibres 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.

Cost: R650 000
Term: 2014 – 2017

Solar energy for desalination and water purification

University of Pretoria
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

Cost: R500 000
Term: 2015 – 2017

Programme 3:
Drinking water quality

Extending EDC Toolbox I to include thyroid and androgenic bioassays

University of Pretoria; Griffith University
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

Cost: R430 000
Term: 2014 – 2016

Nano-membranes hyperbranched polymer integrated system for water remediation

University of Johannesburg; Stellenbosch University

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.

Cost: R600 000
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

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.

Cost: R1 000 000
Term: 2015 – 2018

Programme 4:
Water distribution and distribution systems

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

University of Cape Town
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.

Cost: R1 280 000
Term: 2014 – 2017

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

University of Cape Town

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.

Cost: R700 000
Term: 2014 – 2016

Updating WRC water demand management software for latest operating systems

WRP Consulting Engineers (Pty) Ltd

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.

Cost: R520 000
Term: 2014 – 2015

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
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.

Cost: R900 000
Term: 2015 – 2018

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
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.

Cost: R998 950
Term: 2008 – 2010

Urban effluent treatment in a rhizofiltration system

Durban University of Technology; Stellenbosch University; University of Cape Town
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 is 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.

Cost: 2 400 000
Term: 2010 – 2012

Exploring knowledge on natural processes for novel approaches to constructed wetland design and performance for wastewater using biomimicry

Golder Associates
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.

Cost: R3 000 000
Terms: 2011 – 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)
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.

Cost: R1 200 000
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
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

Cost: R2 000 000
Term: 2014 – 2017

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

City of Cape Town; University of the Western Cape
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

Cost: R2 500 000
Term: 2014 – 2019

Biomimicry wastewater treatment technology – monitoring & evaluation

Isidima Design & Development (Pty) Ltd
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.

Cost: R500 000
Term: 2015 – 2017

Programme 2:
Application of appropriate technologies and tools

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

University of Cape Town
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.

Cost: R1 426 987
Term: 2013 – 2016

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

Durban University of Technology
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.

Cost: R1 600 000
Term: 2014 – 2015

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

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

Cost: R500 000
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

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.

Cost: R1 600 000
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

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.

Cost: R860 000
Term: 2015 – 2017

Endocrine disrupting compound removal by wastewater treatment plants

Tshwane University of Technology; University of Pretoria (Medical)

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.

Cost: R550 000
Term: 2015 – 2017

Programme 3:
Stormwater and sewerage systems

A functional description of urban effluent treatment in a rhizofiltration system

Stellenbosch University

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.

Cost: R749 200
Term: 2014 – 2015

Sanitation technology assessment and evaluation

Partners in Development (Pty) Ltd
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

Cost: R1 315 600
Term: 2014 – 2015

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
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.

Cost: R950 000
Term: 2015 – 2016

Characterizing municipal wastewater sludge for sustainable beneficial agricultural use

University of Pretoria; ERWAT
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

Cost: R1 500 000
Term: 2015 – 2018

Programme 5:
Sanitation technology and innovations

Piloting and testing the pour flush latrine technology for its applicability in South Africa

Partners in Development
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.

Cost: R1 000 000
Term: 2009 – 2011

Demonstration and scaled-up implementation of pour-flush sanitation in South Africa

Partners in Development
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.

Cost: R1 475 175
Term: 2012 – 2013

Energy generation using low-head hydro technologies

University of Pretoria
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.

Cost: R500 000
Term: 2013 – 2015

Eastern Cape school sanitation – pour flush pilot

Maluti GSM

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.

Cost: R372 100
Term: 2015

The development of wastewater anaerobic digestion for greater energy, water and nutrient recovery

University of Cape Town

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.

Cost: R1 454 486
Term: 2015 – 2018

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

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.

Cost: R354 000
Term: 2011 – 2014

Integrated bioremediation and beneficiation of bio-based waste streams

Rhodes University

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)

Cost: R750 000
Term: 2013 – 2016

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

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.

Cost: R900 000
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

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.

Cost: R900 000
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

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.

Cost: R900 000
Term: 2015 – 2017

Revision of Natsurv 9: Water and Wastewater Management in the Poultry Industry (Edition 2)

VitaOne8 (Pty) Ltd

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.

Cost: R900 000
Term: 2015 – 2017

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

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.

Cost: R1 400 000
Term: 2013 – 2016

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

University of KwaZulu-Natal (Pietermaritzburg)
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.

Cost: R700 000
Term: 2013–2015

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

Quantitative Evidence Research cc
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.

Cost: R306 000
Term: 2014 – 2015

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)
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.

Cost: R400 000
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
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

Cost: R850 000
Term: 2013 – 2016

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

University of Johannesburg
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, easier to synthesise and more readily available than single-walled carbon nanotubes.

Cost: R1 000 000
Term: 2014 – 2017

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

Vaal University of Technology
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.

Cost: R1 200 000
Term: 2014 – 2017

Shale water treatment

University of the Western Cape (SAIAMC); Wageningen University

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.

Cost: R2 421 875
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

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.

Cost: R900 000
Term: 2015 – 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

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

Cost: R2 565 000
Term: 2013 – 2017

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

VitaOne8 (Pty) Ltd

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 10 ML/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

Cost: R1 557 600
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
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.

Cost: R1 247 513
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

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.

Cost: R1 033 000
Term: 2012 – 2015

Continuous eutectic freeze crystallization

University of Cape Town

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.

Cost: R2 276 600
Term: 2013 – 2018

Improving evaporation rates of mining wastewaters

University of the Western Cape

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.

Cost: R1 795 960
Term: 2014 – 2018

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

University of the Western Cape

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.

Cost: R765 362
Term: 2014 – 2018

An integrated bioprocess for AMD remediation and renewable energy generation

University of Cape Town

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.

Cost: R2 372 862
Term: 2014 – 2019

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

University of Cape Town

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.

Cost: R1 754 440
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
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.

Cost: R950 000
Term: 2014 – 2018

Programme 4:
Mining in the 21st century

Paques pilot and demonstration plant

Project Assignments SA (Pty) Ltd; Paques bv
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.

Cost: R2 800 000
Term: 2015 – 2018

Electro-coagulation pilot and demonstration plant

Tecroveer

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.

Cost: R2 800 000
Term: 2015 – 2018

Ettringite process pilot and demonstration plant

Miwatek

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.

Cost: R2 800 000
Term: 2015

Alternative reverse osmosis pilot and demonstration plant

Miwatek

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.

Cost: R2 800 000
Term: 2015 – 2016

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

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

Cost: R500 000
Term: 2014–2016

NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1:
Cost-recovery in water services

Proof-of-concept of the application of Strategic Adaptive Management in the water services sector prior to full-scale demonstration

Amanzi Obom Consulting cc; Department of Water and Sanitation (Western Cape); SALGA; AWARD; Stellenbosch University (Civil Engineering); IMESA; Department of Cooperative Governance and Traditional Affairs

1123

Project aims:

- Review literature (especially as it relates to case studies) and clarify and map the concepts and processes of Strategic Adaptive Management (SAM) and Adaptive Management (AM)
- Prove or disprove that the SAM concept is applicable to water services by modifying SAM to enable a truncated process and co-create a strategy related to a national government programme through a series of workshops

Cost: R300 000
Term: 2016 – 2017

Programme 2:
Institutional and management issues – Water services

Assisting municipalities to determine the most appropriate indicator for funding allocations toward operations and maintenance

PDG

1121

Project aims:

- Consolidation and review of existing literature for determining appropriate allocations towards operations and maintenance
- Provide clarity on definitions and the manner in which indicators are calculated and applied
- Recommend appropriate indicators to be used and the context in which this can be applied

Cost: R237 318
Term: 2016 – 2017

Piloting and refining a school sanitation management model

Partners in Development (Pty) Ltd; KZN Department of Education (Infrastructure); University of KwaZulu-Natal (Pietermaritzburg)

2575

Project aims:

- To observe the impact of a range of management interventions as opposed to infrastructure interventions -- on the degree to which learners enjoy conditions that support their health, safety and dignity in their experience of school sanitation
- To test the use of tools that have been developed to assist with the management of school sanitation and evaluate and refine their design with feedback from implementers
- To explore the beliefs and attitudes of principals with regard to service and status, responsibility, authority and agency and the impact of these on the way they address learners' needs (for health, safety and dignity) with regard to school sanitation; to engage principals with regard to their role; and to evaluate the impact of the exploration and engagement on principals' beliefs and attitudes
- To explore the impact of sanitation management on learners' experience of dignity and respect
- To empower participating principals and SGBs with the attitudes, knowledge and tools to be able to manage school sanitation successfully and model their success to others in their district
- To explore opportunities within the structures and systems of the KZN Department of Education (DoE) to provide greater support to schools with regard to sanitation, particularly in terms of financial, monitoring and accountability structures and systems, as a model which could be replicated in other provinces
- To provide South African DoEs and rural schools with a tested sanitation management programme which protects the health, safety and dignity of learners
- To influence policy development in the DBE and provincial DoEs to more strongly support effective management of school sanitation

Cost: R1 000 000
Term: 2016 – 2018

Assessing the affordability of water to the residential sector based on consumption

PDG; University of Cape Town
2584

Project aims:

- Provide an assessment of the current status of residential water affordability in South Africa
- Estimate the economic value which households assign to water and the degree to which there is variability in such value, based on various household income bands and socio-demographic characteristics
- Investigate the means by which water affordability can be measured in terms of consumption and whether there are opportunities for the improved measurement thereof through the use of municipal billing data and census information
- Provide recommendations for the means by which household water affordability can be improved to enhance the livelihoods of South African households

Cost: R861 000
Term: 2016 – 2018

A review, alignment and reform of the national and international water supply and sanitation monitoring and reporting requirements: Alignment of the water and sanitation functions to respond to new national (NDP; NWRS2) and international (SDG) obligations

Sustento Development Services cc

2588

Project aims:

- To review South Africa's future national and international water services monitoring and reporting obligations
- To develop a Monitoring and Reporting Framework to address South Africa's future national and international water services monitoring and reporting obligations
- To determine and address the gaps in current water services monitoring and reporting frameworks to ensure that future WSS monitoring and reporting requirements can be met
- To develop tools and a guideline to facilitate the implementation of the WSS Monitoring and Reporting Framework
- To test the WSS Monitoring and Reporting Framework tools and guideline
- To develop a training and capacity building guideline to facilitate implementation of the WSS Monitoring and Reporting Framework

Cost: R893 900
Term: 2016 – 2018

Mitigating the impact of electricity disruption on water supply – case study of the City of Tshwane

Umfula Wempilo Consulting; University of Pretoria; City of Tshwane

2591

Project aims:

- Evaluate the risk to water supply posed by short-term and long-term electricity supply disruption
- Determine suitable institution arrangements to mitigate impacts
- Determine appropriate infrastructure design changes
- Estimate the costs of such measures and prioritise the steps to be followed
- Develop appropriate institutional and design guidelines

Cost: R800 000
Term: 2016 – 2018

Programme 3:
Innovative management arrangements – Rural water supply

The Internet of things: opportunities for the WASH sector

CSIR

2779

Project aims:

- Study Internet of things (IoT) in relation to WASH services
- Report on IoT opportunities related to WASH services

- Report on potential challenges, successes and failures related to IoT enabled WASH services
- Present a future view of IoT in a WASH context

Cost: R300 000
Term: 2017 – 2018

Programme 5:
Water services education and awareness

Impact of behavioural messaging on water consumption and technology uptake: evidence from a randomized experiment in South Africa
University of Cape Town; University of Sussex
2596

Project aims:

- Reach a formal agreement with City of Cape Town which ensures full financial buy-in and support going forward
- Implement measures to ensure that knowledge and skills transfer occur that will allow for the integration of behavioural interventions within the ambit of the City's DSM tools/strategies
- Examine how different behavioural messages influence residential water usage across all income groups over the long term
- Compare the impact of a tariff increase on water consumption to the impact of behavioural messaging
- Consider the impact on consumption of using behavioural messaging in conjunction with a tariff increase (relative to relying solely on a tariff increase)

Cost: R2 000 000
Term: 2016 – 2019

THRUST 2:
WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1:
Drinking water treatment technology

A comparative life cycle assessment (LCA) for the provision of potable water from alternative sources (seawater, wastewater and mining water) in South Africa
University of KwaZulu-Natal (Howard College); Veolia Water; Umgeni Water; eThekwini Municipality
1122

Project aims:

- To generate environmental information by investigating each of the water treatment technologies (desalination, recycling of wastewater and reclamation of mine water)
- To improve the overall environmental performance of these processes
- To guide designers and owners of these potential life-cycle environmental consequences of the selected technologies

- To develop capacity in undertaking life-cycle assessments

Cost: R200 000
Term: 2016 – 2018

Modelling advanced oxidation of persistent chlorohalogenated pollutants in aqueous systems

University of Pretoria (Chemical Engineering); Sedibeng Water

1125

Project aims:

- To conduct batch reactor system design and optimisation of operational parameter using systematic preliminary studies
- To perform batch studies and kinetic determinations of the photocatalytic sequence and system performance on the oxidation of polychlorinated substituted phenols in aqueous systems
- To determine reaction mechanism, evaluate and develop a sufficient mathematical model for the photocatalytic transformations of each chlorophenol

Cost: R200 000
Term: 2016 – 2017

An assessment of fungal occurrence in treated drinking water in Johannesburg West and implications to public health

UNISA (Florida); ARC Animal Production Institute

2568

Project aims:

- To identify sampling sites along the treated drinking water distribution network in Johannesburg West. Sites to include taps (point-of-use), pressure control sites along the distribution network, and inlet and outlet points at drinking water treatment plants
- To collect treated drinking water samples and determine the densities of fungi and total and faecal coliforms
- To use molecular methods to characterise the fungi isolates to species level and determine the presence of mytoxigenic fungi
- To analyse water samples for traces of different types of mycotoxins
- To statistically determine any correlations between the presence of coliforms and fungi in treated drinking water and the potential health impacts
- Make output-dependent recommendations about monitoring and the potential health impacts of fungi in drinking water distributions

Cost: R600 000
Term: 2016 – 2019

Guidance on drinking water treatment systems performance assessment and optimisation

Water Group Holdings (Pty) Ltd; CSV Water Consulting Engineers

2578

Project aims:

- To provide the best practices and processes for the assessment of drinking water treatment systems in South Africa

- To align assessment methodology and practice with the Blue Drop regulatory approach

Cost: R1 000 000
Term: 2016 – 2018

Framing desalination within the water–energy–climate nexus

EScience Associates (Pty) Ltd; University of Cape Town
2778

Project aims:

- Review and report of legal frameworks within which the planning and implementation of seawater desalination and associated environmental impacts are managed
- Water–energy–climate change nexus in the context of desalination, with emphasis on the potential role of desalination within a broader climate change adaptation strategy, considering both periods of drought and flood episodes
- Opportunities for energy generation, when the assurance of water supply in the nexus is raised through the introduction of seawater desalination
- Comparisons of the energy requirements for different desalination technologies, and emerging strategies for achieving:
  - » Energy efficiency through the use of energy reduction/recovery technologies and emerging energy efficient desalination technologies
  - » Sustainability through the use of renewable energy technologies
- Formulation of a research framework for desalination in South Africa including a stakeholder engagement process
- Formulation of policy recommendations for achieving water–energy–climate change security in South Africa

Cost: R300 000
Term: 2017 – 2018

Programme 2:
Water treatment for rural communities

Development of resource guidelines on greywater use and management

University of Cape Town; Stellenbosch University
2592

Project aims:

- Compile a report on the legislative context of greywater use and management in South Africa, including:
  - » Definition of terms and concepts
  - » Role of greywater management in water supply and food security
  - » Applicable regulations/ordinances/guidelines on greywater use and management
  - » Existing greywater use and management systems
  - » Recommendations for sustainable greywater use and management
- Develop guidelines for greywater use and management, taking into consideration the following aspects:

- » Greywater quantity/quality and fitness for use/ application
- » Managing risks and uncertainty in greywater use/ reuse
- » Use of greywater to supplement irrigation activities
- » Greywater management options, including treatment, disposal and reuse
- » Protocols for testing and validating treatment technologies
- » Guidance for household use and municipal greywater programme implementation in both sewered and non-sewered settlements

Cost: R263 000
Term: 2016 – 2017

Development of resource guidelines for rainwater harvesting

CSIR
2593

The project aim is to develop a guideline document for establishing a municipal rainwater harvesting programme in both rural and urban settings, including:

- Specific codes or regulations for rainwater harvesting
- Rainwater harvesting infrastructure financing and related financial incentives/programmes
- To investigate the factors that must be considered when planning for rainwater harvesting, including institutional, technical, financial, social aspects, climatic conditions, etc., and develop recommendations based on each
- To develop user resource material on rainwater harvesting, covering system design and installation, system components, maintenance, allowable uses, owner responsibilities, and permitting requirements
- For each water use category, identify the water quality requirements; necessary on-site treatment options and likely perceived public health concerns

Cost: R344 000
Term: 2016 – 2017

Programme 3:
Drinking water quality

Antibiotic resistant bacteria and genes in raw and drinking water: Implications for water production and water quality monitoring

North-West University (Potchefstroom); Rand Water
2585

Project aims:

- To determine the physico-chemical and general microbiological parameters of the different water sources at the time of collecting water for the ARB resistance tests, qPCR and environmental metagenomic analysis
- To isolate and to determine the antibiotic resistance profiles of isolated bacteria for comparison to the next generation molecular evaluation methodologies
- To perform qPCR and environmental metagenomic analysis of DNA isolated directly from water and evaluate the analysis processes

- To evaluate the next generation molecular method data and determine the implications thereof
- Use the data for determining whether mitigation strategies are required and if this is positive then evaluate the options that are available

Cost: R1 526 000
Term: 2016 – 2019

A scoping study on microplastics in water environments

North-West University (Potchefstroom)
2610

Project aims:

- As part of the literature survey, to scan the literature on existing definitions of microplastics and particles. These definitions will be listed and discussed as to differences and concurrences.
- To conduct a comprehensive literature survey, including grey literature such as reports, on microplastics and microparticles in the aquatic environment. Much has already been done on marine microplastics and particles, and this will be translated into potential issues in the freshwater. estuarine, and coastal environment and water cycles of South Africa. Attention will also be given to drinking water, potential impacts on human health and the environment.
- To compile an annotated compendium of relevant sampling and analytical methods (water, sediment, and biological materials), with specific attention as to the situation and conditions in South Africa.
- To sample and analyse microplastics and microparticles in a variety of sediments and freshwaters, including drinking and groundwater.
- To construct a synthesis of the above, translated to the situation in South African fresh, estuarine and coastal waters and water cycles, including potential threats to human health and biota. Priorities will be identified, as well as possible and potential mitigating actions.
- To compile a list of research entities working on microplastics in South Africa.
- To develop proposals as to the standardisation of methods and preliminary criteria for target site/stretch/area selection.

Cost: R300 000
Term: 2016–2017

Programme 4:
Water distribution and distribution systems

Interpretation of logging results as a water distribution system management tool

WRP Consulting Engineers (Pty) Ltd
1124

Project aim:

- Summarise the findings of this study in a practical, usable document that includes step-by-step guides to use logging results to identify and resolve water network problems

Cost: R300 000
Term: 2016–2017

Leakage characterization of bulk water pipelines

University of Cape Town
2572

Project aims:

- A literature review of the latest research on the relationship between pressure, leakage rate, and leakage area
- Design of equipment suitable for testing bulk pipelines
- Construction of the equipment and verification in the laboratory
- Pilot testing of the equipment on a bulk pipeline
- Testing several bulk pipelines of different materials, diameters and ages to determine their leakage characteristics
- Guidelines for condition assessment of pipelines using the methodology explained in this application

Cost: R1 335 000
Term: 2016 – 2019

Establishing the frequency and causes of contamination and intrusions in water distribution systems

University of Cape Town
2573

Project aims:

- A literature review of the latest research on contamination intrusion and its impact in water systems
- Establishing the frequency and magnitude of intrusion events and the characteristics of water distribution systems that contribute to these events
- Identify the critical aspects of intrusion mechanisms, including driving forces, contamination paths and contaminants near pipes
- Provide guidance on best practices of water quality control in water distribution systems using the Water Safety Plan (WSP) as a useful framework for risk assessment
- Develop expertise on water quality and hydraulics in water distribution systems

Cost: R750 000
Term: 2016 – 2018

THRUST 3:
SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1:
Emerging treatment technologies – Preparing for the future

Mathematical modelling for trace elements and organic compounds in wastewater treatment plants in Gauteng

University of Johannesburg; Vaal University of Technology
2563

Project aims:

- To evaluate every stage of WWTP process in terms of heavy metals content; this will assist in getting the complete picture (mass balance) about the occurrence, fate and transport of heavy metals and organics
- To relate the process and controller dimensions for the WWTP units to retention time for the heavy metals
- To carry out in-depth sampling at the different WWTPs using different intervals based on retention time from liquid, mixed sludge and dewatered sludge
- To carry out experimental analysis of samples for heavy metals and organic substances to determine the load levels
- To mathematically model the heavy metal flow rates and the incidence of sludge production in the WWTP process; this will take into account hydraulic retention time (HRT) and loading rates.
- To simulate WWTP parameters using the CHEMCAD computer code/software to calculate the mass balance based on the experimental data (results) obtained from the laboratory analysis
- To compare experimental results with simulated data from CHEMCAD in order to ascertain comparability of satisfactory results; this will allow for validation and parameter optimization
- To optimize parameters and validate empirical results through chemical modelling so as to ascertain comparability of satisfactory results
- To analyse the optimized results using chemometrics based on sum of square errors (SSE); after optimization, recommendations of the treatment process and the model will be completed and assessed for the activated sludge technology

Cost: R995 000
Term: 2016 – 2019

Development of a two-stage nitritation-Anammox process for improved ammonia removal from wastewater

Durban University of Technology; Columbia University
2565

Project aims:

- Identification of suitable growth/operational conditions to selectively enrich ammonia oxidising bacteria (AOB) and Anammox bacteria from mixed consortia

- Selective enrichment and optimization of growth conditions for AOB and Anammox bacteria in separate bioreactors
- Integration of enriched AOB and Anammox reactors into a two-stage continuous nitritation-Anammox process and evaluation of the potential for scale-up
- Comparison of the performance of the integrated (two-stage) reactor to the conventional single-stage Anammox reactor

Cost: R1 850 000
Term: 2016 – 2019

Getting the most out wastewater treatment plants and anaerobic digesters with biodegradability tests

University of Cape Town; University of KwaZulu-Natal (Howard College)
2595

Project aims:

- Modify the fully integrated physical, chemical and biological processes anaerobic digester (AD) simulation model developed in the previous WRC project (K5/1822) to simulate the BMP test
- Develop an augmented biomethane potential (ABMP) test experimental procedure to determine the unbiodegradable fraction and hydrolysis rate and composition (x,y,z,a,b,c in $C_xH_yO_zN_aP_bS_c$) of the biodegradable organics to predict AD performance
- Develop an augmented biosulphide potential (ABSP) test apparatus and procedure to determine unbiodegradable fraction and hydrolysis rate and composition of the biodegradable organics without the error-prone gas measurements of the BMP and ABMP tests
- Build a settleometer to separate the settleable organics in municipal wastewater into different settling velocity groups
- Determine with the ABMP and ABSP tests the unbiodegradable fraction and hydrolysis rate and composition of the biodegradable organics of different settling velocity groups in municipal wastewater
- Code a primary settling tank (PST) model that begins to resemble reality by predicting higher removals of unbiodegradable organics (60–80%) than biodegradable organics (40–60%)
- Include the PST model into the fully integrated physical, chemical and biological processes plant-wide WWTP simulation model developed in the previous WRC project (K5/1822) to better predict activated sludge and AD system performance in plant-wide WWTPs

Cost: R1 800 000
Term: 2016 – 2020

Programme 2:
Application of appropriate technologies and tools

Treatment and reuse potential of urine and faecal fractions from urine-diversion dehydrating toilets in eThekwini Municipality

University of Kwazulu-Natal (Westville); eThekwini Municipality; Khanyisa Projects; Agriprotein
2586

Overall objective: To better understand the microbial risk associated with the beneficiation of faecal sludge from urine-diversion dehydrating toilets (UDDT) using black soldier fly larvae (BSFL) and struvite reactors. The benefits associated with reuse will be balanced against health risks associated with all stages of faecal sludge and urine handling and processing. Objectives are:

- To optimize, as far as practical, the conditions which promote the ability of BSFL to digest UDDT faecal sludge in a manner suitable for up-scaling to field conditions
- To optimize, as far as practical, the conditions which maximize the growth conditions of BSFL grown on mixed UDDT and a readily bioavailable organic substrate
- To measure levels of health-related organisms in UDDT faecal sludge, BSFL and BSFL-digested residual sludge, and to assess the health implications for householders, farmers and /or workers using processed by-products
- To monitor the fate of the pathogen indicators during urine processing, including measuring levels in struvite and struvite-depleted urine; this includes developing an understanding of how these respond to drying of struvite under different combinations of temperature and relative humidity
- To develop broad health-based guidelines on how UDDT faecal sludge and source-separated urine can be processed safely for beneficiation

Cost: R328 000
Term: 2016 – 2018

The implications of chemical composition of different types of greywater for seed germination and growth of crop plants

University of Kwazulu-Natal (Westville); eThekwini Municipality

2590

Project aims:

- Identify suitable greywater sources to be sampled, and suitable chemical techniques for investigating greywater composition; techniques should particularly address the presence of inorganic cations, and anionic, cations and non-ionic surfactants
- Measure seed germination, plant growth and plant physiological responses in response to irrigation with the greywater from sources identified above
- Assess the effect of simple treatment steps (probably on-site filtration through sand and gravel, or through biochar) on the chemical composition of different greywater types and on their effect on seed germination, plant growth and plant physiological responses
- Produce guidance to policy-makers, local authorities and users regarding which greywater types are best for irrigation, which constituents in greywater are the most harmful to plants and should therefore be avoided, and simple on-site treatment steps to mitigate adverse effects from constituents to plant growth

Cost: R345 000
Term: 2016 – 2018

Effects of reduction of wastewater volumes on sewerage systems and wastewater treatment plants

VitaOne8 (Pty) Ltd

2626

Project aims:

- To identify and quantify physical infrastructure based impacts on the conveyance and treatment systems resulting from drought and water conservation and demand management measures such as reduced wastewater influent flows and quality
- To identify and quantify operational and maintenance based impacts on the conveyance and treatment systems resulting from drought and water conservation and demand management measures using models such as the sewer network model and/or WWTP model to map scenarios
- To assess health, environmental and financial impacts associated with both drought and water conservation and demand management measures such as reduced wastewater influent flows and quality
- To determine and identify practical adaptive interventions applicable for negative impact mitigation within the framework of the South African best practices and operational requirements
- To develop material which could be used to create awareness on drought and water conservation and demand management measures on wastewater services and proposed mitigation measures applicable within the South African municipal wastewater treatment industry

Cost: R300 000
Term: 2017

Programme 3:
Stormwater and sewerage systems

User interface design of communal ablution blocks (CABs) in urban South Africa

University of Cape Town; City of Cape Town Metropolitan Municipality

2569

Project aims:

- Develop improved design criteria for CABs, based on critical reflection on the user interface, informed by specialist ethnographic, engineering, architectural and industrial design expertise
- Develop prototypes of CABs
- Prepare design guidelines for CABs, for use in local authorities

Cost: R910 000
Term: 2016–2018

Securing water sustainability through innovative spatial planning and land use management tools – case study of two municipalities

i@consulting; North-West University (Potchefstroom)

2587

Project aims:

- To motivate that spatial planning legislation (Spatial Planning and Land Use Management Act, No. 16 of 2013) can become the backbone for a water-sensitive South Africa

- To address water-conscious land-use planning by re-evaluating the role of spatial planning in a water-sensitive manner
- Prove that water-sensitive planning is a short-term investment with long-term economic, social and environmental benefits for all municipalities
- Prove that integrating spatial planning and infrastructure planning (water) by means of land use planning can and will mitigate the demands on water resources
- Educate communities and stakeholders in clever water use, and reduce overall water demand
- Ensure a work-integrated learning environment for students in the spatial planning profession by gaining experience to be experts in their field of study (water-land relationship), and in this sense, enhancing the higher education sector's response to water-sensitive planning

Cost: R2 000 000
Term: 2016–2019

Assessment and control of inappropriate discharges into storm drains

Cape Peninsula University of Technology; City of Cape Town Metropolitan Municipality
2600

Project aims:

- Develop new procedures for identifying priority areas in urban sub-catchment with low, medium and high risk of inappropriate discharges
- Develop methodologies and techniques for identification, detection, monitoring and control of inappropriate discharges
- Collate data into a comprehensive guideline for assessment and control of inappropriate discharges into stormwater drains

Cost: R1 202 439
Term: 2016 – 2019

Programme 4:
Wastewater sludge and faecal sludge management

An investigation into the impact of sludge return flows on South African wastewater treatment works

Royal HaskoningDHV (Pty) Ltd
2581

Project aims:

- Assess the impact of the return flows from sludge handling/treatment (such as dewatering liquors and digestion rejection flows) in the WWTP biological treatment, i.e., aeration capacity, required biological volume and effluent quality
- Use the existing WRC plant-wide model to predict the impact of the sludge handling/treatment return flows on the biological treatment
- Identify the applicable technologies for nitrogen and phosphorus removal from return flows within the framework of South African best practices and operational requirements
- Identify the potential applications for recovered

nutrients, legal outlook and market value
- Cost balance for nutrient recovery solutions, including capital and operation costs, as well as sell earnings

Cost: R1 360 000
Term: 2016 – 2019

Programme 4:
Sanitation technology and innovations

Performance assessment of DEWATS constructed wetlands

University of KwaZulu-Natal (Howard College); eThekwini Municipality; BORDA; Asian Institute of Technology; Trinity College Dublin

2579

Project aims:
- Monitor the performance of the Newlands Mashu constructed wetlands
- Compare the performance with generally accepted design approaches
- Highlight gaps or shortcomings in the design techniques
- Provide guidance as to the design and operation of constructed wetlands serving dense social housing or informal settlements

Cost: R994 500
Term: 2016 – 2019

Drying and pasteurization of faecal sludge using solar thermal energy

University of KwaZulu-Natal (Howard College); eThekwini Municipality

2582

Project aims:
- Establish a solid bibliographic background on solar thermal energy and its application for faecal sludge processing
- Design, build and validate a solar drier prototype
- Characterize solar drying and pasteurization of the faecal sludge
- Establish guidelines for upgrading the system (e.g. costs, technical aspects, ideal locations for installation, use of the product)

Cost: R657 000
Term: 2016 – 2018

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 2:
Integrated management

A feasibility study to evaluate the potential of using water-sensitive design principles to strengthen water planning for the Waterberg Industrial Complex (or DM)

Golder Associates Africa (Pty) Ltd; Biomimicry SA; University of the Witwatersrand; University of Johannesburg

2765

Project aims:

- Provide a baseline assessment of the Waterberg catchment
- Using a set of tools designed as part of the Watershare partnership, develop a conceptual water
- -sensitive design for the area which integrates water resource protection and supply, stormwater management, wastewater treatment and biodiversity protection
- Engage and share water-sensitive design concept, framework and guidelines with relevant
- stakeholders and ensure buy-in of all stakeholders through project cycle
- Set specific WSD WQ objectives for the selected area with realistic design and performance objectives; a comparative analysis between conventional design objectives and WSD objectives should be done
- Screen and evaluate feasibility of implementing the WSD options in the Waterberg District Municipality and with current catchment partners by assessing amongst others the institutional arrangements, the planning and management practices, and the appropriate technology options available to meet design, cost and performance objectives
- Link knowledge and partnerships to WRC Community of Practice Programme in this domain (hosted by UCT Urban Water Management Research Unit on behalf of the WRC)

Cost: R1 368 000
Term: 2017 – 2019

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

Brine systems and treatment processes

University of Cape Town; Eskom; Environmental and Nanosciences Research Group; University of Istanbul

2576

The main aim of the research is to review, characterize and model a range of South African brines and wastewaters with a view to evaluating suitable treatment technologies. This will be achieved as follows:

- Review the current state of South African brines, including their composition and location
- Select a suite of representative South African brines (as recommended in the WRC/Eskom workshop) and

carry out a full water characterisation on each of the brines
- Carry out a thermodynamic analysis of the case study brines and proposed potential treatment processes
- Work in collaboration with Eskom in order to establish which of the brines are suitable for treatment using EFC technology

Cost: R2 004 283
Term: 2016 – 2019

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

Description and quantification of drought shocks in South African industries

The Pegasys Institute NPC
2604

This project aims to quantify the impacts of droughts on South African industries, including agriculture but also outside of agriculture, in terms of impacts on production, cost of raw materials, export earnings, unemployment, profits, real non-indexed wages, consumption of products, and investment, among others. The outputs of the project (8 fact sheets), will be used with targeted industries and institutions in providing compelling reasons to act early in the event of meteorological drought warnings. The 8 fact sheets will be based on an extensive literature review and economic analysis of the impact of drought on different sectors in South Africa. The study will also consider the different hydro-climatic zones of South Africa, and the divergent nature of droughts within these areas. By describing the societal and economic impacts of a drought on particular sectors and regions, improved actions to mitigate the potential impacts will be possible. Overall, the expected impact of the above outcomes will be a more proactive and responsive suite of sectors of the economy in relation to drought in the future.

Cost: R600 000
Term: 2016 – 2017

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

Photo-PROTEA

University of the Western Cape; French National Centre of Scientific Research; Cape Peninsula University of Technology
2562

Project aims:
- Assess the efficiency of the Life-Phytobarre bioremediation process on Western Cape winery and olive-mill wastewaters
- Study the evolution of the microbial communities according to the type of waste (winery and olive-mill), and relate to seasonal changes
- Identify if indigenous microorganisms participate in the biodegradation; isolate the key organisms and then reformulate the initial photosynthetic bacterial consortium

- Set up an outdoor lab-scale experiment to establish a proof-of-concept on a 100 L volume capacity

Cost: R700 000
Term: 2016 – 2019

Electrochemical unit operations in industrial wastewater treatment: the development of electrocoagulation and photoelectrochemical oxidation reactors based on novel nanocomposite electrodes

University of Johannesburg; Radical Waters; University of the Western Cape; University of Bath; University of Campinas

2567

Project aims:

- The general aim is to develop and integrate electrocoagulation and photoelectrochemical oxidation unit operations based on novel mixed nanomaterials into a reactor system for the treatment of industrial wastewater
- To incorporate electrocoagulation as a unit operation into water treatment in a jar test experiment
- To evaluate the performance (metal removal, COD removal, turbidity removal etc) of electrocoagulation over coagulation using simple electrode configuration and novel carbon cathode
- To understand the morphology, chemical and electrochemical behaviours of novel nano-carbon materials and composites for photoelectrochemical oxidation
- To understand the applicability of these materials as photoanodes and cathodes under various conditions as it relates to wastewater treatment
- To evaluate the performance of photoelectrochemical oxidation unit operation in a jar test experiment for wastewater treatment
- To evaluate the efficiency of (solar) photoelectrochemical reactors developed from these materials in the presence of selected standard dye/ organic polluted water and real sample wastewater
- To interrogate the kinetics, degradation products and mechanism of the degradation processes
- To generate data that can explain the performance of a pre-pilot reactor consisting of both electrocoagulation and photoelectrochemical unit operations towards different types of wastewater
- To study the effect of different reactor configurations based on different material combinations

Cost: R160 000
Term: 2016 – 2019

Reclamation of industrial process water from solid and liquid effluents, through integrated bio-energy production

Stellenbosch University; Elgin Fruit Juices (Pty) Ltd; Paper Manufacturers of South Africa

2570

Project aims:

- To design and construct an experimental anaerobic biodigester module consisting of 8 x 50 L reactors;

no such experimental system exists in SA, and will serve this project as well as several to follow very well, leading to greater industrial roll-out of the technology
- To develop and scale up the optimised process developed (in a different investigation) for production of bioethanol from a range of paper sludge wastes to 100 L bioreactor scale
- Determine potential biogas yield from paper sludge wastes, and from fermentation residues remaining after bioethanol production from each of these feedstocks, using 50 L reactors
- Characterise the final residues (solid and liquid components) of anaerobic biodigestion and determine the suitability for, and extent of water reclamation, and suitability of water and solid residues from these biofuel production processes for industrial and/or agricultural application
- Determine energy yield from combustion of solid residues of anaerobic biodigestion
- Stakeholder engagement in the fruit industry in the Western Cape, to determine the scope and level of buy-in for ethanol production from fruit wastes

Cost: R1 000 000
Term: 2016 – 2019

Water recovery from flue gas evaluation

University of the Western Cape (SAIAMC); DNV GL; Eskom
2571

Project aims:
- Modification of a laboratory-scale testing facility
- Produce laboratory-scale membrane modules suitable for water recovery from model flue gas
- Completion of a flue gas treatment facility
- Produce upscaled membrane modules suitable for water recovery from flue gas
- Integration of the flue gas facility into the Lethabo power station
- Demonstrate the water recovery from real flue gas using the integrated gas treatment facility at Lethabo power station

Cost: R3 670 000
Term: 2016 – 2019

Optimising the use of fish to harvest algae from industrial effluent treatment ponds

Rhodes University
2574

Project aims:
- Develop a process that makes the algae in post-high rate algal ponds more available to fish
- Optimize the process of converting algal biomass into fish biomass, so that we are in a position to pilot the technology

Cost: R550 000
Term: 2016 – 2018

Smart bio-nanocomposites for organic dye remediation

UNISA (Florida)

2583

The main aim of the project is to develop smart bio-nanocomposites for organic dye remediation which will involve a visible light driven photocatalyst based on rare earth doped carbon nanotubes and titania, immobilised on biopolymers such as chitosan, alginate, cyclodextrins, etc. This photocatalyst will be evaluated for the degradation of various azo dyes. The aim of the project will be addressed through the following specific objectives which are:

- To prepare rare earth (Eu, Gd, Ce, Nd, La, etc.) doped carbon nanotubes via a simple wet impregnation method followed by thermal decomposition and reduction in hydrogen
- To prepare rare earth doped carbon nanotube/titanium dioxide nanocomposites via a sol gel method
- To immobilise the rare earth doped carbon nanotube and rare earth doped carbon nanotube/titania on biopolymers using crosslinking agents such as hexamethylene diamine and gluteraldehyde
- To evaluate the bare and polymer immobilised photocatalysts for the degradation of various azo dyes in synthetic solutions under visible light irradiation

Cost: R900 000
Term: 2016 – 2019

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1:
Water use and waste production

Irrigation with poor quality mine water in Mpumalanga

University of Pretoria; University of the Free State (Institute for Groundwater Studies)

2564

Project aims:

- To identify key considerations for locating intermediate- to large-scale mine water irrigation schemes in the landscape based on geo-hydrological characteristics, and identification of monitoring requirements and thresholds for action for such schemes
- To assess, on a small experimental scale, the use of untreated acid mine drainage (AMD) on limed soil, limed and clarified AMD, and limed and unclarified AMD still containing metal hydroxide sludge on crop growth and soil properties
- To monitor and model field-scale water and salt

balances for two small-scale mine-water irrigation schemes (30 ha on rehabilitated land and 30 ha on unmined land) in Mpumalanga, in order to predict the long-term impact and sustainability of mine-water irrigation
- To quantify the economic sustainability of irrigation with mine-water

Cost: R6 200 000
Term: 2016 – 2021

Programme 3:
Minimising waste production

An assessment to determine if pit lakes are a solution to coal mine closure in South Africa

GCS Water and Environment (Pty) Ltd; University of the Free State (Institute for Groundwater Studies)
2577

Project aims:
- Identify six existing pit lakes for the field investigation of water quality, temperature, pH, ORP and dissolved oxygen
- Determine if final mine voids (pit lakes) are a viable option for coal mine closure in South Africa
- Develop a guideline for the design of coal mine pit lakes in South Africa

Cost: R1 240 350
Term: 2016 – 2019

Resource efficient and socially responsible approaches for the integrated management of mine waste: Understanding the opportunities, enablers, barriers and risks

University of Cape Town
2580

Project aims:
- Identify key opportunities, drivers, enablers and barriers for the valorisation of mine waste in the South African context
- Establish potential roles of the relevant stakeholders (government, mining industry, SMEs) in enabling the implementation of effective management approaches for mine wastes
- Develop a more detailed understanding of the inter-relationship between mine waste, environmental degradation and community impacts (health and livelihoods)
- Enhance current tools for assessing the potential metal and salt-related risks posed by coal wastes, and build an inventory database for such wastes in the local context

Cost: R1 277 837
Term: 2016 – 2018

Programme 4:
Mining in the 21st century

Development and application of new materials for selective removal of trace elements from mine wastewater

University of the Witwatersrand; CANSA; Impala Platinum Ltd

2589

Project aims:

- To assess the water quality in water systems impacted by mining activities (gold and platinum mining).
- To modify and functionalise natural zeolite and bentonite using various ligands based on pollutants and precious metals
- To conduct static (batch) studies using natural and functionalised zeolite and bentonite for synthetic and environmental samples
- To conduct dynamic (column) studies using natural and functionalised zeolite and bentonite for synthetic and environmental samples
- To conduct desorption studies to assess the potential re-usability of the adsorbents
- To conduct chemometric and geochemical modelling to characterize water quality and to assess long-term aspects
- To deploy the adsorbents to impacted mining sites

Cost: R862 250
Term: 2016 – 2019

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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.

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
- To increase profitability of water-based farming systems
- To ensure sustainable water resource use through protection, restoration and reclamation activities

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 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 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.

RESEARCH PORTFOLIO FOR 2016/17

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

Nutritional water productivity of indigenous food crops

ARC Roodeplaat Vegetable and Ornamental Plant Institute; ARC Institute for Soil, Climate & Water; Medical Research Council

2171

Sub-Saharan African (sSA) countries are facing three interrelated challenges, namely, water scarcity, population growth, and food and nutritional insecurity of essential micronutrients (Fe and Zn) and Vitamin A. Agricultural production needs to increase and has to be achieved against a backdrop of issues such as climate change (extreme weather, flooding, and droughts), soil fertility depletion, and land degradation. Micronutrient (Fe and Zn) and Vitamin A deficiencies affect resource-poor households (RPHs) who are located in less favourable areas characterized by poor soil fertility and low yield, as well as lack of capital and agricultural inputs (specifically water and fertilizer). Therefore, agriculture needs to re-think agro-biodiversity solutions when planning a food-based approach in curbing micronutrient deficiency. Traditional vegetable crops (TVCs) are highly nutritious in terms of Fe, Zn, and β-carotene and are drought tolerant (can withstand adverse environmental conditions), when compared to exotic vegetables. However, this assumption has been based on the fact that some TVCs grow naturally in marginal environments that are characterized by poor soil fertility, while depending solely on sporadic rainfall. In 2012, the WRC funded a project (TT/535/12) titled 'Nutritional value and water use of African leafy vegetables for improved livelihoods'. Key findings of the project were that these TVCs have the potential of providing more than 50% of the recommended daily allowance for Fe, Zn, and Vitamin A. However, these findings were based on plant samples taken from locations where soil fertility and actual evapotranspiration, or crop water use, were unknown. As such, further research was needed to better understand the link between management practices, water, soil nutrients, biomass, and nutritional content of TVCs. *Beta vulgaris* (Swiss chard) was used as a reference crop because it is a leafy vegetable, highly nutritious (contains

Fe, Zn and β-carotene), commercialized in South Africa and mostly utilized by RPHs who eat it as a relish with maize porridge.

Cost: R1 950 000
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
2172

While there is not much evidence of widespread starvation and extreme undernutrition in South Africa, national surveys provide evidence of multiple forms of deprivation related to the experience of hunger, widespread manifestation of hidden hunger or micronutrient deficiencies and increasing rates of 'overweight' and obesity. Moreover, the co-existence of adult (especially female) 'overweight' and obesity with hidden hunger and child malnutrition raises serious concerns over household food security. Despite a multitude of state, private sector and non-governmental agency (NGO) funded food security programmes, South Africa is one of only 12 countries in the world where stunting has increased over the Millennium Development Goal (MDG) period. It is also the only country in the Southern African Development Community (SADC) region where child stunting has not decreased. The increasing incidence of 'overweight' among women and children raises alarm. This indicates severe inadequacies related to the diets of South Africans and highlights the importance of understanding the constraints faced by households in achieving food security to ensure health, productivity and development. A baseline and scoping study commissioned by the WRC (K5/1954/4) has revealed numerous knowledge gaps with regard to smallholder production and food security in South Africa. The study highlighted that there is limited current and generalisable food security and nutrition research in South Africa. Very few studies have investigated the year-round source(s) of food for the rural poor. In particular, agricultural interventions to improve human nutrition and the (indirect) eventual outcomes of health, education and economics are practically non-existent. The study identified two specific knowledge gaps. Firstly, it identified that the contribution of home- or smallholder-grown foods to total dietary intake and nutritional requirements (in the context of an in-depth description of the food environment and its links to water) is not known. Secondly, the effect of seasonality on home or smallholder production is not documented. This project set out to address this significant and longstanding gap in knowledge and to propose a set of options for strengthening rain-fed and irrigated crop production in the rural areas investigated, and to identify the research focus areas related to efficient water use that could directly overcome dietary inadequacies and lead to better nutrition of rural household members. This unique study drew on a transdisciplinary research approach to investigate the consumption and production patterns of rural households in communities in four selected sites in the poorest local municipalities in South Africa.

Cost: R3 650 000
Term: 2012 – 2016

Water use and crop parameters of pastures for livestock grazing management

University of Pretoria; University of KwaZulu-Natal (Howard College); ARC Livestock Business Division; Department of Agriculture, Western Cape

2173

Irrigated agriculture is facing fierce competition for a substantial share of water as the water demand for industrial, domestic, municipal and other activities is increasing rapidly. The increasing shortage of irrigation water in addition to the increasing cost of fertiliser creates a great need to improve the practices of irrigation through better understanding of crop water requirements and ultimately better irrigation scheduling. Cultivated pastures form the base of feed for many livestock production enterprises in South Africa, comprising more than one sixth of the country's total irrigated land, making it one of South Africa's highest value crops. To ensure sustainable pasture production to produce sufficient pasture to supply the protein demand more efficiently for a growing population, innovations will be required to increase the efficiency of water and nitrogen use in such pasture production systems used in the livestock industry. To save on nitrogen fertilizer costs, much attention has been given to self–nitrogen fixing legume hay crops and mixed grass-legume pastures. These pasture management practices are not always very economical from both a quantitative and qualitative perspective, but are becoming more economical, especially in the light of sustainability. Lucerne. which is regarded as the most important legume hay crop, has for many years been the pasture crop most frequently irrigated. Lucerne, however, is known for its high water usage compared to other pastures. The current irrigation guideline for lucerne is a very rigid and for mixed legume-grass pastures non-existent.

Cost: R2 750 000
Term: 2012 – 2016

Programme 1:
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; Winelands UV Technology; Cape Peninsula University of Technology

2174

The aim of this project was to conduct a scoping study of different on-farm treatment options to reduce or remove the high levels of potentially pathogenic micro-organisms from irrigation water. This was achieved by conducting a comprehensive literature study and survey of potential on-farm treatment options for irrigated water contaminated with high levels of micro-organisms to enable a treatment option to be selected for the trials in an exploratory study; conducting an exploratory study of an on-farm treatment option (in this case, ultraviolet (UV) light) by monitoring the water quality throughout the irrigation water cycle; determining the efficacy of different treatment options (including hydrogen peroxide, chlorine, peracetic acid, hydrogen peroxide/UV, peracetic acid/UV and chlorine/

UV and UV as single treatment) on different *E. coli* strains (reference strains, environmental strains and mixed environmental strains) at laboratory-scale and using river water in a custom pilot-scale irrigation water test unit; and proposing the most appropriate treatment options and requirements for further research.

Cost: R2 250 000
Term: 2012 – 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; University of KwaZulu-Natal (Pietermaritzburg); Forestlore Consulting
2081

There is a lack of information on riparian tree water use for indigenous trees in South Africa. This study provided long-term water use for three different forest types, each at differing levels of rehabilitation. The techniques used were heat pulse velocity, stem steady state and thermal dissipation. A modelling component was used to upscale the data from individual trees to stands and catchment scales. The results showed that indigenous trees in an established riparian stand in a Western Cape Afro-temperate forest can use high volumes of water throughout the year (little seasonal rainfall change in this region). The variability of water use between species and tree size was large as this variable is largely dependent on location, tree condition and light dynamics. This further highlights the need for measurement replication. The comparison between individual trees indicated that the largest trees (*Celtis* and *Vepris*) used the most water. However, when extrapolated by stem density, the alien species (*Acacia mearnsii*) used significantly more water per unit area (up to five times more water in certain stand locations). The modelling results revealed that a significant amount of water can be conserved if alien-invaded forest stands are rehabilitated. Of particular importance, during the wetter season (May to August), the deciduous trees in the winter rainfall region were not using any water. This is in contrast to the deciduous species in the Eastern Mistbelt region and the Maputaland coastal belt that are dormant during the dry season when water is most scarce. In the Western Cape area, it is recommended that evergreen species be used for forest rehabilitation as they use less water than the deciduous trees during the drier months when water is needed the most.

Cost: R5 900 000
Term: 2011 – 2016

THRUST 3:
WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1:
Sustainable water-based agricultural activities in rural communities

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 (Mafikeng); University of KwaZulu-Natal (Howard College)

2176

Close to half of South Africa's population (45%) resides in rural areas. In KwaZulu-Natal, 56.7% of the total population and 54% of women reside in rural areas. In South Africa, an estimated four million people engage in smallholder agriculture and the majority of these people are in rural areas. The most common reason given for engaging in agriculture is to procure 'an extra source of food'. More than half of the rural households in South Africa are headed by women and are among the poorest. Women make up a substantial majority of the agricultural workforce and produce most of the food that is consumed locally. In developing countries, about 43% of women are working in agriculture. The large proportion of agricultural production that is attributable to woman makes them the principal agents of food security and household welfare in rural areas. However, lack of skills, especially agricultural, among rural women results in poor performance and negatively affects their livelihoods and that of their households. The New Growth Path for South Africa identified employment creation as possible, both within economic sectors as conventionally defined and in cross-cutting activities, and analysed the policies and institutional developments required to take advantage of these opportunities. The agricultural value chains were identified as job drivers through the restructuring of land reform to support smallholder schemes with comprehensive support around infrastructure, marketing and extension, to upgrade employment in commercial agriculture, especially through improved worker voice and supporting growth in commercial farming, while addressing price fluctuations in maize and wheat. This will target 300 000 households in smallholder schemes by 2020; agro-processing anticipates creation of 145 000 jobs by 2020 and upgrading employment on commercial farms will create a total of around 660 000 jobs. It is expected that these projections will adequately cover women farmers, since they form the bulk of the smallholder farmers. Gender issues are now mentioned in most national and regional agricultural and food-security policy plans, but they are usually relegated to separate chapters on women, rather than treated as an integral part of policy and programming. Many agricultural policy and project documents still fail to consider basic questions about the differences in the resources available to men and women, their roles and the constraints they face, and how these differences might be relevant to proposed interventions. As a result, it is often assumed that interventions in areas such as technology, infrastructure and market access have the same impacts on men and women, when in fact they might not.

Women's access to productive resources, such as land, modern inputs, technology, education and financial services, is a critical determinant of agricultural productivity. Agriculture is important to women, but female farmers have less access to the productive resources and services required for agricultural production. Women are less likely than men to own land or livestock, adopt new technologies, use credit or other financial services, or receive education or agricultural extension advice. In some cases, women do not even control the use of their own time. While the size of the gender gap differs by resource and location, the underlying causes for the gender asset gap are repeated across regions, and social norms systematically limit the options available to women. Regardless of cause or magnitude, however, the gender asset gap reduces the agricultural productivity of women and thus involves broader economic and social costs.

Cost: R3 000 000
Term: 2012 – 2016

Action-oriented strategy for knowledge dissemination and training for skills development of water use in homestead gardening and rainwater harvesting for cropland food production

Rhodes University; Umhlaba Consulting Group (Pty) Ltd

2277

The report provides insight into the actual knowledge mediation and dissemination processes that were pilot tested during the project. Key amongst these was the establishment of a learning network structure that was inclusive of all stakeholders in the agricultural learning system. Within this, a Training of Trainers (ToT) programme was established to mediate the WRC knowledge and to support the stakeholders in the agricultural learning system to take up and use the WRC knowledge. In the agricultural colleges, lecturers were supported to develop curriculum innovation programmes which included shared demonstration site development. Other stakeholders (extension officers, LED officers, researchers, farmers and farmers association members) were also included in the training of trainers where they too were supported to develop learning support innovation projects and to participate in the shared demonstration site development process. This brought the value of working in learning networks to the fore, as different stakeholders were able to mobilise their prior knowledge, experience and expertise in a local context, where the end results were contributions to improved farming practice amongst farmers, knowledge exchange between farmers, improved curriculum options for college students and better support to smallholder farmers to use RWH&C knowledge in a local context. However, it was only possible to implement one such learning network in some depth over a period of 18 months, but shorter ToT programmes were run, and other learning networks were emerging at the time of the project's end. A key extension to the above was the development of a media component for facilitating the expansion of access to, and use of, the WRC materials. This involved development of project branding which re-named the initiative 'Amanzi for Food', allowing quick access and association with the key message of the project, an associated and dedicated website (www.amanziforfood.co.za) which allowed multi-levelled access to the materials via various access tools. This included a 'navigation tool' which proved to be critical to the whole knowledge access and dissemination process, links to other social media, including a Facebook page, blogs

and news items, and links to other websites where the WRC knowledge is being shared. Posters and YouTube videos were also developed and pilot tested to assist with visualisation of the RWH&C practices. Additionally, a community radio programme was established with a radio handbook produced out of the experience of designing and hosting the radio programmes. A significant finding of the media component is that the various forms of media operate in relationship, requiring an integrated approach to media development for enhancing knowledge dissemination.

Cost: R1 950 000
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 Limpopo Province

Umhlaba Consulting Group (Pty) Ltd; Tshwane University of Technology; University of Pretoria
2179

The research project resulted from a directed call for proposals. The general aim was to review and evaluate appropriate development paths for expansion from homestead food gardening to smallholder irrigation farming, increased water use productivity of crop production and improved livelihoods on selected smallholder irrigation schemes in South Africa. The findings show that irrigation is strongly associated with improved livelihood outcomes and a strengthened human, physical and financial capital base. The incomes of irrigator households were significantly higher with all irrigator households above the upper-bound poverty line, whilst home gardeners were on or below this line. Irrigator households were also more food secure with greater food diversity than home gardener households. Entrepreneurial farmers with varied characteristics, but sharing a business outlook, were identified in similar numbers to classical peasant-farming categories, with true capitalist farmers a rarity. Constraints were severe and were dominated by institutional disincentives in the acquisition of secure land and in obtaining secure water supply. The wholly inadequate, even chaotic, communal land-tenure arrangements, combined with high risks related to inadequate irrigation water supply, turn development pathways into somewhat treacherous endeavours. Relocation of promising farmers onto well-established (medium or large-scale) schemes, fundamental reforms in communal land-tenure systems on smallholder schemes, investment in water management institutions, marketing support, and water management interventions are all strategies that would have to be pursued in parallel to achieve results. Irrigation can, it seems, provide the much sought-after development outcomes. However, it will demand political will of iron to totally re-institutionalise the smallholder sector and allocate large budgets for the parallel essential investments that are needed to launch and drive smallholder irrigation development trajectories into the future.

Cost: R2 144 000
Term: 2012 – 2016

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; University of KwaZulu-Natal (Durban); Stellenbosch University; OABS (Pty) Ltd
1882

Based on the results from this study, increasing temperatures and changes in precipitation are very likely to reduce cereal crop productivity. This will have strong adverse effects on food security. The fact that the majority of the arable land in the country is rain-fed, with increasing variability projected under climate change conditions, suggests that the livelihoods of farmers who depend on rain-fed agriculture will be threatened and the percentage of the population experiencing hunger and under-nourishment may increase. It is important to determine the possible impacts on different agricultural systems under projected future climates and evaluate suggested climate change adaptation strategies. The results from this study show that more than 70% of smallholder farmers across the study sites have low adaptive capacity. This group of farmers are vulnerable due to lack of financial resources, limited access to technology and also insufficient climate change adaption strategies, especially for table grape farmers. Climate change is expected to exacerbate existing climate-related problems in the country where more than 60% of the population are found in rural areas and are dependent on agriculture for their basic livelihood. Several climate change projections show that temperature and rainfall patterns in Southern Africa by 2050 indicate a significant decline in the production of major staple crops such as maize, wheat and sorghum. Climate change is expected to not only impact on crop and livestock production, but also alter the agriculturally-related socio-economic environment and general livelihood of the majority of poor households. This study proposes several coping and climate change adaptation strategies based on agricultural commodities and also agro-ecological zones (AEZ).

Cost: R4 300 000
Term: 2009 – 2016

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)
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.

Cost: R2 072 000
Term: 2011 – 2016

Water footprint of selected vegetable and fruit crops produced in South Africa

University of Pretoria (Plant Production and Soil Science)
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.

Cost: R2 750 000
Term: 2013 – 2017

Determining water use of indigenous grain and legume food crops

University of KwaZulu-Natal (Crop Science)
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.

Cost: R2 750 000
Term: 2013 – 2017

Quantifying citrus water use and water stress at tree and orchard scale

Citrus Research International

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.

Cost: R2 750 000
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)
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.

Cost: R3 000 000
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)
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.

Cost: R3 000 000
Term: 2014 – 2018

Water use of strategic biofuel crops

University of KwaZulu-Natal (Pietermaritzburg)
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.

Cost: R4 000 000
Term: 2015 – 2020

Programme 2:
Fitness-for-use of water for crop production, livestock watering and aquaculture

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)
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.

Cost: R2 750 000 (incl. leverage)
Term: 2012 – 2016

Knowledge transfer on water quality management for improved integrated aquaculture and agriculture systems

Stellenbosch University (Aquaculture)

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

Cost: R1 950 000
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)

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.

Cost: R2 000 000
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 grasslands after eradication of alien invasive trees

Rhodes University (Institute for Water Research)
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.

Cost: R4 300 000
Term: 2014 – 2019

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

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, 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.

Cost: R5 000 000
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

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)
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.

Cost: R3 070 465 (incl. leverage)
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)
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.

Cost: R1 950 000
Term: 2013 – 2017

Water use of crops and nutritional water productivity for food production, nutrition and health in poor rural communities

University of KwaZulu-Natal (Crop Science)
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.

Cost: R4 000 000
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)
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.

Cost: R2 600 000
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)

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.

Cost: R4 000 000
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

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.

Cost: R4 000 000
Term: 2015 – 2020

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)
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.

Cost: R1 950 000
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
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.

Cost: R1 950 000
Term: 2013 – 2017

The optimisation of electricity and water use for sustainable management of irrigation farming systems

University of the Free State (Agricultural Economics)
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.

Cost: R1 950 000
Term: 2013 – 2017

Wide-scale modelling of water use and water availability with earth observation/ satellite imagery

Stellenbosch University (Environmental and Geographical Studies)

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.

Cost: R5 010 940 (incl. leverage)
Term: 2014 – 2018

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
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.

Cost: R3 000 000
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

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.

Cost: R4 000 000
Term: 2015 – 2020

Programme 2:
Impact assessment and environmental management of agricultural production

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)

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.

Cost: R2 950 000 (incl. leverage)
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)

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.

Cost: R2 200 000
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)

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.

Cost: R2 000 000
Term: 2014 – 2018

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

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.

Cost: R4 500 000
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

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.

Cost: R890 000
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
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.

Cost: R4 000 000
Term: 2015 – 2019

THRUST 1: WATER UTILISATION FOR FOOD, FORAGE AND FIBRE PRODUCTION

Programme 1:
Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of avocado and macadamia orchards

University of Pretoria; ARC; University of KwaZulu-Natal (Pietermaritzburg); independent consultant

2552

Cost: R5 160 000
Term: 2016 – 2021

The general aim of this research is to quantify water use of avocado and macadamia trees in relation to yield at an orchard scale. Specific project aims are:

- To measure unstressed water use of avocado and macadamia according to seasonal growth stages from planting to mature canopy size, for selected cultivars and locations
- To model stressed water use of avocado and macadamia according to seasonal growth stages from planting to mature canopy size for selected cultivars and locations
- To determine the influence of water stress during different phenological stages of avocado and macadamia on yield and quality for selected cultivars and locations
- To quantify water use efficiency and water use productivity of avocado and macadamia for selected cultivars and locations

Assessing the water footprints of selected fuel and fibre crops in South Africa

University of the Free State; SASRI; ARC

2553

Project aims:

- To assess the green-, blue- and grey-water footprint of selected fuel and fibre crops and their respective derived crop products in South Africa
- To develop water footprint benchmarks for sustainable freshwater use in the production of the selected fuel and fibre crops in South Africa
- To develop benchmarks for the economic productivity of the water footprints of the selected fuel and fibre crops
- To conduct a sustainability assessment of the blue-water footprint of food and fibre production in South Africa
- To identify and prioritize key strategic intervention points in the food and fibre production chain for the most efficient results

- To model the economic and social implications associated with changed water use behaviour through the implementation of recommended intervention strategies to change water use behaviour towards sustainable freshwater use
- To assess the water footprints of selected fuel and fibre crops in the context of projected future climate change scenarios in South Africa

Cost: R3 000 000
Term: 2016 – 2021

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-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

University of Pretoria; University of KwaZulu-Natal (Pietermaritzburg); Hydrological Research & Training Specialists
2554

The aim of the study is to understand and quantify the water use of different agricultural and ecological land-use components of the Maputaland Coastal Plain, which could potentially be developed into an integrated, multiple-use agroforestry system(s), as an alternative to commercial plantation forestry in water-stressed catchments.

Project objectives are:

- Understand with accuracy the water use of plantation forestry and indigenous species within a commercial, community woodlot and mixed plantation or agroforestry environment in Maputaland
- Understand the ecological pattern and water use of natural vegetation systems that could be incorporated in agroforestry systems in Maputaland
- Develop and evaluate groundwater models of the Maputaland Coastal Aquifer to determine the impacts of land use in the context of plantation forestry, natural vegetation systems and a mixed plantation environment

Cost: R2 408 000
Term: 2016 – 2019

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1:
Sustainable water-based agricultural activities in rural communities

Water use for food and nutrition security at the start-up stage of food value chains

University of KwaZulu-Natal (Pietermaritzburg); ARC Institute for Soil, Climate & Water; Free State Department of Agriculture

2555

Project aims:

- Conduct a detailed literature review of techniques and practices (homestead, community and school gardens) to improve water use for food and nutrition security at the start-up stage of food value chains, for early childhood development and household food security and livelihoods enhancement in peri-urban and rural environments
- Describe and analyse the current natural resources (water, soils, climate), human resources (demographics, gender, age, vulnerability, agency, current social reality, state of health, nutritional status and needs etc.), institutional arrangements, farming systems and water use in homestead, community and school gardens and food value chains at start-up level
- Identify and select climate-smart technologies and practices to improve water use for improved crop production to match dietary and nutritional needs for early childhood development and for improved households and livelihood enhancement
- Demonstrate and implement selected technologies for improved production at homestead, community and school gardens in the selected areas, for improved household and livelihood enhancement
- Evaluate, monitor and analyse water use for food and nutrition security at the start-up stage of food value chains at homestead, community and school gardens, for improved households and livelihood enhancement
- Explore the role of homestead, community and school gardens in producing sufficient food and in entering the food value chain for producers in the selected areas, for improved households and livelihood enhancement
- Monitor and evaluate the influence of workable institutional arrangements (water, land use security and market players) and organisational structures on incentives and/or disincentives for homestead, community and school gardens, with the intention of entering the food value chain for improved households and livelihood enhancement
- Develop guidelines on best management practices to improve water use for food and nutrition security at the start-up stage of food value chains for improved households and livelihood enhancement

Cost: R3 870 000
Term: 2016 – 2020

Assessment of the effectiveness of policies and strategies for governance of smallholder irrigation farming in KwaZulu-Natal Province, South Africa

University of KwaZulu-Natal (Pietermaritzburg); University of Limpopo; University of Zululand

2556

The overall research aim is to assess the effectiveness of policies and strategies, rules and regulations and governance of programmes that provide support to smallholder farmers on irrigation schemes in KwaZulu-Natal Province. Specific project objectives are:

- To review the existing policies, strategies, rules and regulations and governance of programmes and their influence on the performance of irrigation schemes in South Africa and beyond
- To review literature on the assessment of the effectiveness of policies, strategies, rules and regulations, and governance on irrigation performance
- To describe and explain how policies, strategies, rules and regulations and governance programmes affect irrigation schemes with respect to: land and water allocation and land tenure, intergenerational relationships, gender, tradition and culture
- To describe the factors that influence the effectiveness of policies, strategies, rules and regulations, old or new, focusing on factors such as: how information is communicated to irrigation farmers, gender, generational differences, level of education, household level factors
- To specify appropriate changes to existing policies, strategies, rules, regulations and governance programmes that can enhance the performance of smallholder irrigation schemes in South Africa; this can include recommendations on new policies, strategies, rules, regulations and governance programmes that can enhance the performance of smallholder irrigation schemes in South Africa

Cost: R3 000 000
Term: 2016–2020

Programme 2:
Integrated water management for profitable farming systems

Review and update the South African Irrigation Design Manual and Irrigation User Manual

ARC; Bioresources Consulting; Rural Integrated Engineering (Pty) Ltd

2559

Project aims:

- To update and improve the South African Irrigation Design Manual to ensure that current best practices are employed in the design process which will help safeguard the irrigation industry amid the current over-exploitation of our country's water resources and a decrease in energy availability and the subsequent rise in energy costs
- To update and improve the South African Irrigation User Manual in order to assist both commercial and subsistence irrigation farmers as well as irrigation scheme managers in the quest to meet the stated goals in National Water Resource Strategy 2, of

improved water use efficiency by providing quality and relevant information about current trends and the latest technological developments in the irrigation industry

Cost: R1 990 000
Term: 2016 – 2019

Developing a research agenda for promoting underutilised, indigenous and traditional crops
University of KwaZulu-Natal (Pietermaritzburg)
2603

Project aims:

- To conduct a state-of-the-art literature review on past, present and ongoing work on underutilised, indigenous and traditional crops and their status, potential, challenges and opportunities along the value chain in South Africa; the review will pay particular attention to drought tolerance in indigenous crops
- To develop a list of priority underutilised, indigenous and traditional crops for South Africa. The prioritisation of crops will focus on key areas of crops that are known to be drought tolerant and nutrient dense and that have potential to contribute to food and nutrition security during periods of drought
- Develop mechanisms of identification of local research champions for underutilised crops and strengthening of the current database on professionals working on underutilised crops
- To develop a national guideline and research agenda for prioritising research on drought tolerant and nutrient dense underutilised crops in South Africa. The agenda should align with international initiatives to allow South Africa to tap into global funding for underutilised crops

Cost: R200 000
Term: 2016

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1:
Sustainable water resource use on irrigation schemes and within river catchments

Improving on-farm irrigation water and solute management using simple tools and adaptive learning

University of Pretoria; CSIRO Land and Water

2557

Project aims:

- To deploy farmer-friendly monitoring tools that measure soil water, nutrients and salt
- To develop a system of quick data sharing through on-line visualisation of data from the monitoring tools linked to a virtual discussion, learning and teaching space with skilled facilitators
- To further refine simple monitoring tools to address on-farm farmer experiences
- To determine how this combination promotes learning that improves irrigated farm productivity

Cost: R2 000 000
Term: 2016 – 2019

Salt accumulation and waterlogging monitoring system (SAWMS) development

Stellenbosch University; ARC Institute for Soil, Climate & Water; Griekwaland-Wes Korporatief

2558

Project aims:

- To develop a system that automatically analyses multi-temporal (current and historical) satellite imagery for identifying areas within cultivated fields that are likely to be affected by waterlogging or salt accumulation
- To disseminate information about waterlogged and salt-affected areas to end-users through the development and implementation of a web-based application
- To demonstrate, apply and evaluate the system in suitable irrigation schemes
- To improve the system based on user feedback and make recommendations for national implementation

Cost: R2 386 000
Term: 2016 – 2019

Programme 2:
Impact assessment and environmental management of agricultural production

Modelling of water flows with change in land management in selected river catchments

University of KwaZulu-Natal (Pietermaritzburg); University of the Western Cape; University of Lethbridge; Rhodes University

2560

Project aims:

- To assess how changes in land management alter water flows and the generation and delivery of eco-system services within river catchments
- To quantify how changes in land management modify water flows emphasising base-flow and floods for the ecological Reserve, as well as yield from storage, run-of-river and groundwater extraction
- To quantify how changes in land management modify sediment dynamics, with reference to functioning of aquatic ecosystems, maintenance of infrastructure, sedimentation of dams and production of crops
- To quantify how changes in land management modify water quality with reference to nutrient dynamics and environmental health

Cost: R6 000 000
Term: 2016 – 2021

Use of winery wastewater as a resource for irrigation of vineyards in different environments

ARC Infruitec-Nietvoorbij; Stellenbosch University
2561

The general aim is to assess the fitness for use of augmented winery wastewater for irrigation of different soil types with varying rainfall quantities and leaching levels, based on vineyard performance in terms of yield and wine quality:

- To determine the appropriate level of in-field dilution/ augmentation of winery wastewater with raw water with specific reference to the pH, EC, SAR/PAR and COD
- To measure the change in mainly Na and K status of soils with different clay content, with low/high rainfall and low/high leaching levels with application of augmented winery wastewater
- To develop appropriate management guidelines for using augmented winery wastewater as a resource for irrigation of vineyards
- To refine regulations for general authorisation of augmented winery wastewater for irrigation of vineyards

Cost: R4 000 000
Term: 2016 – 2022

Coping and adaptation strategies for agricultural water use during drought periods

Cape Peninsula University of Technology; Department of Agriculture, Forestry & Fisheries
2602

Project aims:

- Review of the current knowledge of drought and drought occurrence in South Africa, including the review of current drought polices and strategies, national and provincial response strategies
- Review of drought coping and adaptation strategies in dryland cropping systems, irrigation, livestock and mixed systems. Identify potential strategies that can be adopted by South Africa, including strategies from Sub-Saharan Africa and other regions
- Identify policy and research gaps, and make recommendations of what should be done in South

Africa under current drought conditions, and future droughts
- Suggest a national drought response strategy for agricultural water use in South Africa

Cost: R200 000
Term: 2016

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