WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW 2017/18

WATER
RESEARCH
COMMISSION

WATER TECHNOLOGY AND INNOVATION FOR A BETTER TOMORROW

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ISBN 978-0-6392-0029-3

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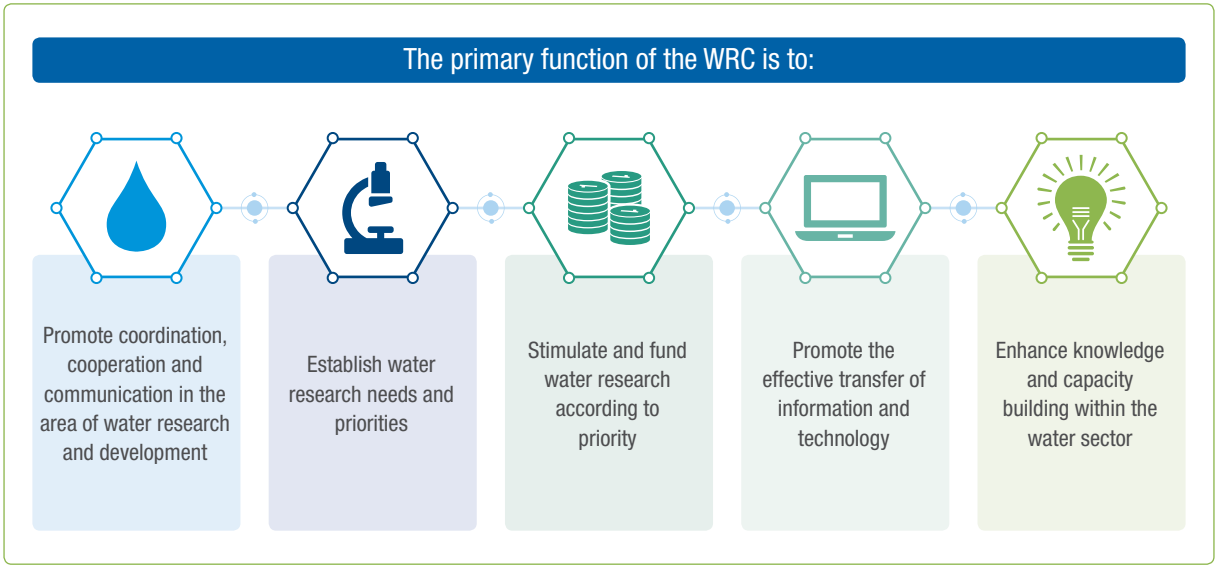
INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2017/18, 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 2017/18 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) which make up the Research and Development Branch: **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management, and Water Utilisation in Agriculture.**



SUPPORTING RESEARCH PROJECTS

In 2017/18, the WRC initiated 85 new projects and also completed 106 projects. Over the past 5 years the WRC has finalised 532 research projects indicating a significant contribution to knowledge in the water sector (Figure 1). Over the same 5-year period 562 new projects were initiated (Figure 2), 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.

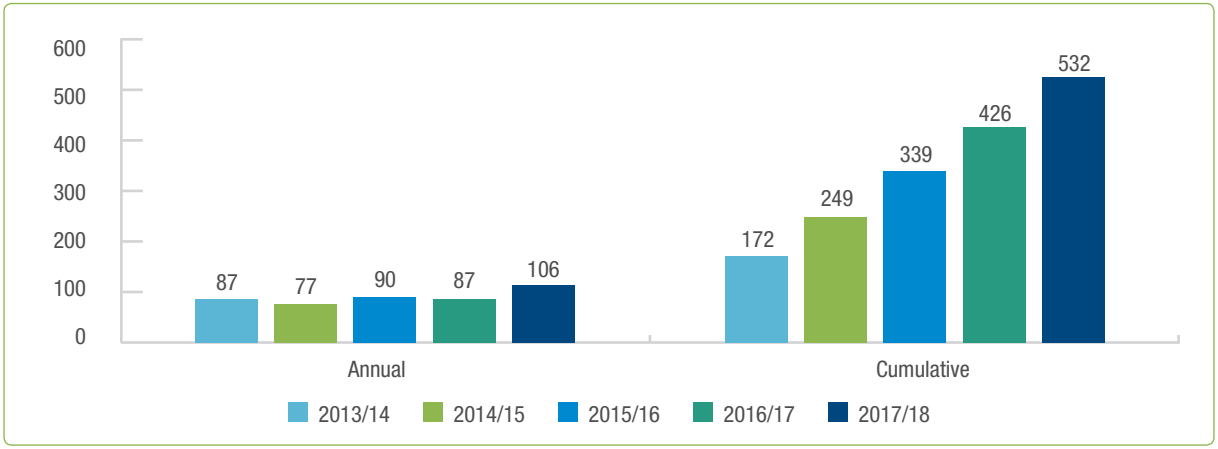


Figure 1. Annual and cumulative number of projects finalised over the past five years

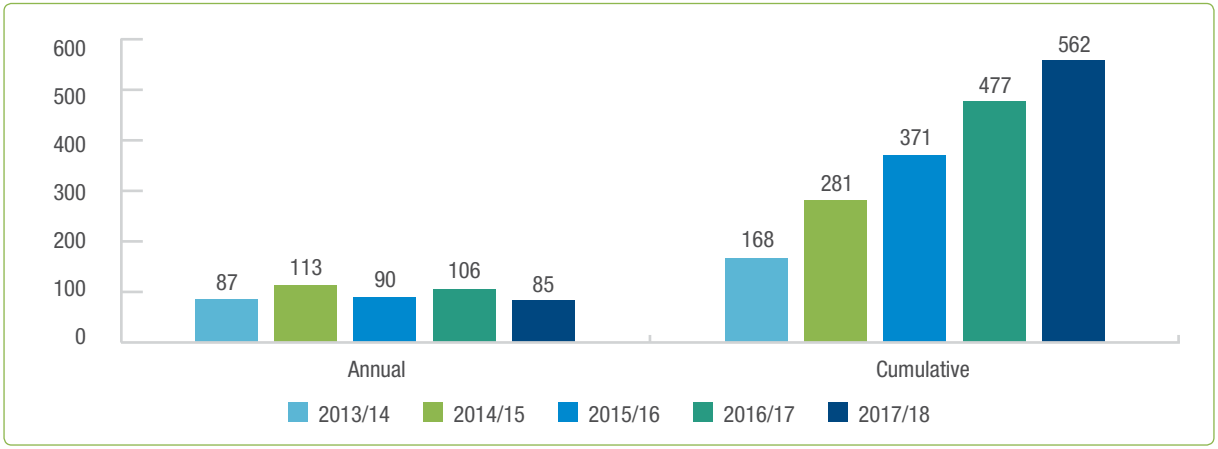


Figure 2. Annual and cumulative number of projects initiated over the past five years

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 (Figure 3), 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.

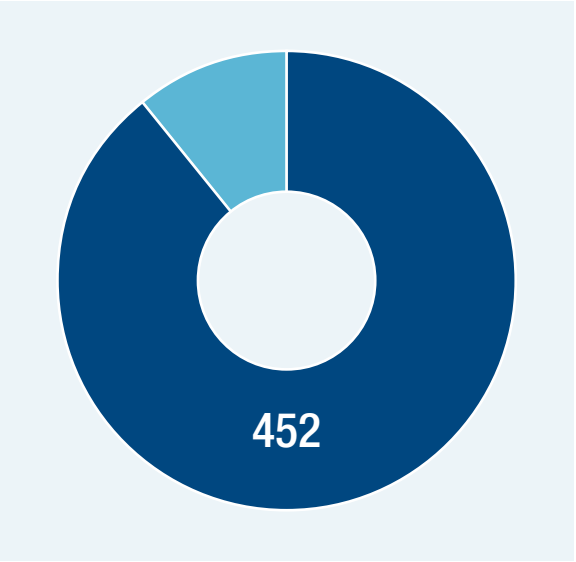
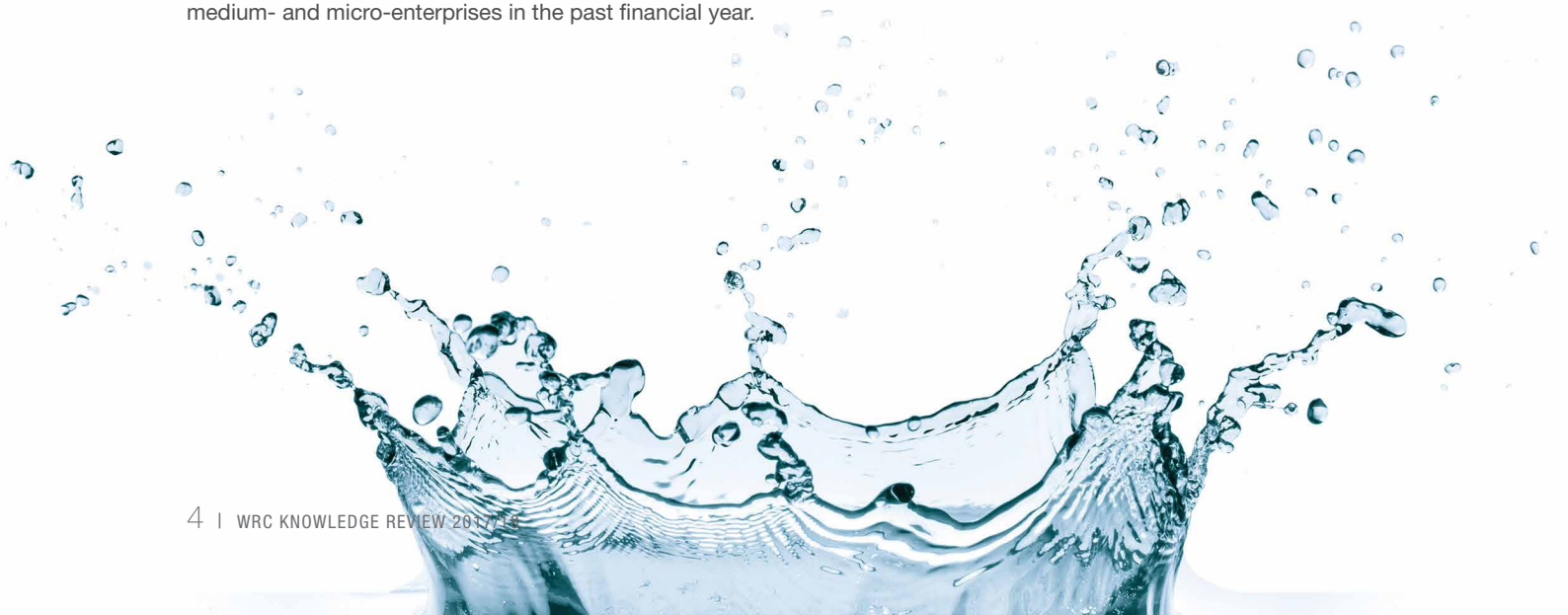


Figure 3: Number of students supported by WRC in 2017/18

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 27 WRC projects were being led by small-, medium- and micro-enterprises in the past financial year.



UTILISATION OF RESEARCH FUNDS

The percentage utilisation of research project funds by the KSAs during 2017/18 indicates that approximately 23% (2016/17: 11%) was invested in projects that focused on Innovation and Impact, whereas 77% (2016/17: 89%) was invested in Research and Development (Figure 4).

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

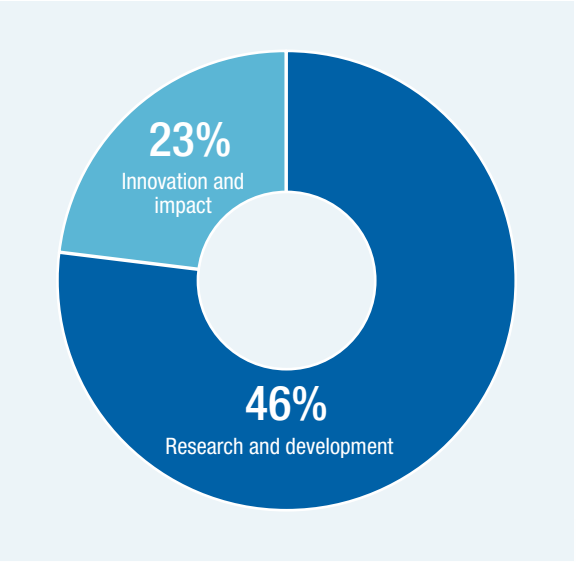


Figure 4: Utilisation of research funds

WRC RESEARCH PORTFOLIO 2017/18

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 2017/18 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

Please note: This list reflects the Thrusts and Programmes for KSA1 for 2017/18. Going forward, KSA 1 and 2 now form a new KSA: Water Resources and Ecosystems, with new 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 2017/18

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Water resources management in South Africa: Towards a new paradigm

Rhodes University; ARC Animal Production Institute; University of the Witwatersrand; AWARD; Cripsis Environment; Dundalk Institute of Technology; HSRC; CSIR; Delft University of Technology; Khulumani Support Group

2248

Integrated water resource management (IWRM) has largely failed in South Africa since it was first embedded in the National Water Act and National Water Policy, way back in 1997. It is most specifically the practice of integration that proved difficult. Water management and water supply still work persistently in silos. The core goals for IWRM in South Africa stated in the NWA are: equity, sustainability and efficient use. These have therefore frequently not been met. However, since the 1990s, a literature emerged that indicated practical integration and progress towards the core goals could be achieved using a set of 'new' concepts. This set of concepts was sufficiently different from the traditional linear and top-down approach to IWRM, to be called 'a new paradigm' for IWRM. Early research and practice in the South African National Parks and the Inkomati-Usuthu Catchment Management Agency was promising and guided this study. This study emphasised demonstrating the integrated approach towards resources management. This demonstration was required in a wider range of case studies, addressing specific intractable problems, to provide confidence that the new practice could be encouraged and actioned nationally in South Africa. The success of the research can and should strongly influence the content and direction of new legislation and the next National Water Resource Strategy. This study engaged the Integrated Water Quality Management Policy and Strategy, led by DWS, as well as development of Catchment Management Strategies, such as that of uMzimvubu to Tsitsikamma. Failure of strong uptake will mean retention of old practices that have resulted in over-allocation and over-use of water; deterioration of water resource health, instream flows and water quality; human health issues related to microbial, eutrophication and other forms of pollution and water insecurity. This project recommends the use of the term Adaptive IWRM to signify the new approach and practice. The results provide clear, positive evidence that investment in further research into, and related practice of, Adaptive IWRM is essential. The project is referred to in the text as TPNP: towards practising a new paradigm. The new practice is Adaptive IWRM. DWS and IUCMA were instrumental in testing the concept in their operations

R5 000 000
2013-2017

Approaches for emerging farmer participation in water resource management: The case of the Breede-Gouritz Catchment Management Agency

Cape Peninsula University of Technology; Breede-Gouritz Catchment Management Agency

2310

Sustainability and equity were identified as central guiding principles of the National Water Act (NWA, 1998). The NWA provided the policy and legislative framework for water allocation. The Water Allocation Reform position paper (2006) outlined strategies and approaches for water allocations, and served as the benchmark for water allocation processes and a formal basis for the implementation of the programme. The study aimed to investigate if the intentions of NWA (1998) in terms of water allocation to address equity and sustainability issues were being realised. The study also set out to investigate if set targets of the Water Allocation Reform Strategy (2008) were being realised. Breede-Gouritz CMA was used as a study area because work done with the CMA revealed that it was also struggling to meet the set targets of water allocation to emerging farmers. The summary of the findings is that emerging farmers support requirements are complex; more than water allocation farmers also require support in related areas like land, financial support and mechanisms of coping with effects of extreme weather events. To address these challenges a farmer support information package was developed with key stakeholders in the province responsible for supporting emerging farmers. Workshops were conducted to share findings and sensitise DWS and other departments to the needs of the emerging farmers they are meant to be supporting. The farmer support information package requires further development to be web-based in order to enable emerging farmers to access information on their cellphones.

R1 303 000
2014-2017

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

Sustento Development Services cc; Prime Africa Consultants cc

2417

This study undertook a water policy review which covered areas of new policy positions which should be considered for sanitation, water supply and water resource management. The recommendations of the review have already been included in the new National Sanitation Policy for South Africa (2016). The Assessment and Review Framework will be used to update national water policy and the Strategy Framework for Water Services and inform the amalgamation of the water legislation.

R1 000 000
2015-2017

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

In drafting a model for the institutional reform of water management policy towards an integrated administrative review mechanism, the prioritizing of the identified principles, procedures and institutional structures necessarily leads one to the development of a framework consisting of multi-tier institutions. These can be divided into judicial, extra-judicial and non-judicial bodies with annexed appropriate dispute resolution mechanisms, and which are co-ordinated by a second-tier supervisory body. The structuring of these multi-level review bodies should attempt to balance the primary requirement of the rule of law, with the need for review at the lowest possible level and in a consensus-seeking manner. These factors dictate the reform of review policy for water governance into a system where a supervisory authority coordinates administrative review into an integrated mechanism where administrative water decisions may be cross-referred for non-judicial, extra-judicial or judicial review, as well as to appropriate dispute resolution methods by appropriate fora. It is recommended that the practical feasibility of this proposed integrated administrative review system should be further investigated with reference to financing, capacity-building, customary dispute resolution mechanisms, competence and other jurisdiction issues.

R300 000
2016-2017

CMA water allocation process requirements and their enforcement

The Pegasys Institute NPC

2536

This project aimed to enhance the existing water use authorisation framework for CMAs (and proto-CMAs) towards more equitable and pro-poor access to water, improving the efficiency of the current system processes, and envisioning shorter turn-around times for licence application processes. To contribute to this aim, the project team embarked on reviewing the existing framework and practices in the CMAs and proto-CMAs to identify strengths, inefficiencies and gaps that could be addressed/improved to achieve an integrated and more effective process for water authorisation by CMAs.

R1 000 000
2016-2017

The challenge of inclusive growth in South Africa: Determinants and outcomes

University of Cape Town

2601

This analysis evaluates how the structure of the South African economy has evolved in the post-Apartheid era. Taking into consideration the various strategies that the government has adopted over time, it attempts to briefly evaluate how the water sector has been affected by these structural changes. It finds that the economic structure of the economy has changed significantly from a primary sector–reliant economy, to a tertiary sector economy. Financial services emerge as the leading sector in the economy, both from an economic growth

perspective and an employment growth perspective. This outcome offers prime opportunities for the water sector in terms of value addition, since financial services is a low-intensity water user, but a high output and job generator. These qualities are instrumental to reducing poverty and inequality. Overall, the evidence suggests that the South African economy is stuck in a low and sluggish growth trap; an indication that there are significant economic constraints acting as stumbling blocks to the country's economic growth. Our analysis evaluates three areas; infrastructural investment, public service delivery, and education and skills development; where economic constraints are most relevant to the water sector. Finally, the analysis considers the role of water in economic growth, by valuing water as a factor of production. We then consider its contribution in the current growth trap scenario. A review of the role of the sector in employment reveals that while the water sector indirectly creates jobs, the inefficient allocation of water means that its potential to create more jobs is not fully exploited. Evidence suggests that the water sector has made great strides in providing the poor with water and sanitation services; hence, inequality in access has significantly reduced since 1994. However, the sector could further improve the welfare of the poor by ensuring that while it develops and extends its infrastructure and services to the uncovered areas, that economic benefits go to the poor as well.

R299 942
2016-2017

Programme 3: Pricing and financing WRM

Towards sustainable economic development in water-constrained catchments: Tools to empower decision making
GreenCape; University of Cape Town
2453

There is increasing recognition that the combined effects of climate change, population growth and continued urbanisation are exerting pressure on limited water resources. At the same time, economic growth remains vital for alleviating poverty, unemployment and inequity. Therefore, growth is required in spite of significant water resource constraints. At issue then is how to allocate water optimally to enable economic growth, while also ensuring that human needs are met and ecological systems maintained. Understanding of the economic impacts of water access is limited, and there is a lack of tools available to address the trade-offs that may be required when allocating water in a water-scarce system. This is needed in particular in 'constrained catchments' where all readily available water is already allocated, such as the case of the Berg River Water Management Area (WMA). In such catchments, future development requires additional water resources, either through the development of new resources or reallocation from other users. A three-year study aimed to better integrate water into economic development planning, and vice-versa. This has been achieved through developing actionable insights and tools for governmental decision-makers that link water availability

to economic outcomes in terms of growth and job creation. The project structure was highly collaborative (action research), utilising research generated by Masters students at the University of Cape Town (UCT) African Climate and Development Institute (ACDI) and adapting the approach and outputs to the evolving requirements of government stakeholders. The Berg River Water Management Area (WMA) was selected as a case study area. Analysis was done on the potential for integration between development planning, water allocation and water resource development processes, with an emphasis on enabling implementation of the findings. The analysis aimed to understand how decision support tools could add value to existing legislated processes by filling knowledge gaps or by providing a collaboration mechanism. This analysis highlighted how the Integrated Development Plan (and SPLUMA) is the key integrated planning tool, but that it is not taking water resource availability sufficiently into account. Furthermore, municipalities, which are also the Water Services Authorities (WSAs), do not have the capacity nor resources to develop their own local water resources, and are struggling to access water from the regional schemes, managed nationally by the DWS. In this context, provincial government has a coordinating and supporting role to play.

R2 059 672
2015-2018

Programme 4: Transboundary water resources

Science diplomacy for transboundary water resource management

Quantitative Evidence Research Consultancy Services cc

2511

The objective of this report was to make a contribution with regard to issues of science diplomacy related to water in the SADC region. Science diplomacy refers to the role of science in three dimensions of policy:

- Science in diplomacy: informing foreign policy objectives with scientific advice
- Diplomacy for science: facilitating international science cooperation
- Science for diplomacy: using science cooperation to improve international relations between countries.

More specifically, the report investigates the extent to which science diplomacy and its current base can support transboundary water resource management in South Africa and the neighbouring states, by identifying the status of scientific and technological collaboration between South Africa and riparian states. A multi-method approach was used consisting of literature review, semi-structured interviews/discussions, and scientometric and survey analyses. As far as research collaboration in Africa is concerned, the relevant literature provides evidence that there is minimal inter-Africa collaboration. Similarly, it has been argued that countries with financial and scientific resources dominate the collaborative efforts in the continent. In the SADC region, South Africa dominates the regional economy and regional scientific system. Currently there

are no efforts to improve collaboration in the region even though the recent SA–Namibia collaboration programme indicates that there is demand for such activities. Setting the above in the South African context shows that SA–SADC co-authorship is a small percentage (6.4%) of South Africa's co-authorship population (52%). Furthermore, it seems that the SA–SADC co-authorship activities are fuelled by international efforts as only 2.4% of SA co-authored activities are between SA and SADC without non-African participants.

R340 000
2016-2017

Programme 5: Future scenarios

Future water allocation trade-off scenarios
ISS; University of Denver
2535

South Africa's water sector is in a precarious state. The country is already overexploiting its renewable resources and, according to the International Futures (IFs) model, withdrawals are forecast to increase in all three sectors (agricultural, industrial and municipal) out to 2035. Meanwhile, much of South Africa's water infrastructure is in disrepair and dam levels are dangerously low – particularly in the Western Cape Province, where dam levels at the end of October 2017 were at an estimated 32%. Furthermore, the existing solutions for reconciling the gap between supply and demand proposed by the South African Government are insufficient. While it is feasible to restore stability to South Africa's water sector, it will take significant investment and political will. This research presents a national-level forecast of water supply and withdrawals in South Africa until 2035, along with exploring some alternative scenarios and their implications for economic and human development.

R1 000 000
2016-2018

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Constructing a baseline of environmental, agricultural and socio-economic intersections for the Mzimvubu Water Project
University of Fort Hare; Rhodes University
2433

Large storage dams, such as those planned under the Mzimvubu Water Project (MWP), impact social and environmental dynamics in the local area. The success of the MWP will not only depend on technical feasibility but also the extent to which it coheres with socio-economic and environmental dynamics – in the short, medium and long term. Since large infrastructure projects are essentially 'long-term, irreversible experiments without a control', it is paramount that robust baselines are established prior to such a project. This was done for the planned Ntabelanga Dam in the Tsitsa River, which will form part of the MWP. The baseline included the quantification of (i) water quality at several sites over two seasons, (ii) stream

geomorphology above and below the planned dam, (iii) aquatic habitat and health status in the Tsitsa River, (iv) vegetation diversity and socio-economic value thereof, (v) carbon stocks under the dam footprint, (vi) wetland water regimes, (vii) soil health status of cultivated fields and natural veld as well as the agricultural production. Socio-economic baseline indicators were captured from local residents which will be impacted by the MWP on different levels. The socio-economic surveys not only serve as baseline for the current situation and perceptions, hopes and fears pertaining to the MWP, but also provide valuable insights to interactions and intersections between the environment, agriculture and socio-economic dynamics in this study area.

R2 000 000
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

Nowcasting constitutes the detailed description of the current weather along with forecasts obtained by extrapolation for a period of 0 to 6 hours ahead. The latest radar, satellite and observational data are powerful tools when operational forecasters have to warn the public of hazardous, high-impact weather such as thunderstorms, tornadoes, lightning strikes and destructive winds. Effective and accurate nowcasting contributes to the reduction of fatalities and injuries, reduction of damage to property as well as improved efficiency for various industries including transport and agriculture. Nowcasting also plays a key role in aviation weather forecasts, both at the terminal as well as in the en-route environment. Ideally, radar systems are the most important part of nowcasting; however, many developing countries and, even more so, least developed countries do not have operational radar systems at all. Some countries, which are fortunate enough to have radar systems, are struggling to maintain these powerful data sources. Geostationary satellite data (from MSG in the case of African countries) provide real-time coverage of the entire African continent that currently updates every 15 minutes and has a resolution of 3 km for most of the 12 channels. Using MSG data, in combination with input from local numerical weather prediction (NWP) models, can be an excellent second option for nowcasting purposes in areas which are not covered by radar data or where no radar systems are available.

R250 000
2015-2017

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

SAEON; University of KwaZulu-Natal (Pietermaritzburg)

2780

The Two Streams catchment experiments in KwaZulu-Natal Province have been used to advance the understanding of the impact of trees on hydrological processes through detailed observations. The catchment, which is located 70 km from Pietermaritzburg, near Seven Oaks on the Greytown road, falls in a summer rainfall, 'midlands mist-belt grassland' region. Streamflow gauging was initiated in 1999 in a mature stand of wattle trees (*Acacia mearnsii*). Following a short calibration period, all the trees in the riparian zone were cleared in July 2000. The trees in the remainder of the catchment were removed in 2004/2005 and the catchment was replanted with wattle in August 2006. Continued monitoring through these changes in the catchment allowed for the questions around what processes allow exotic tree plantations to use more water than grassland areas that they replace and the effects of exotic trees on deep soil water profiles, streamflow and total evaporation. The findings over time have helped to revolutionise our fundamental understanding of catchment hydrology in South Africa and informed national policy related to streamflow reduction activities (SFRAs). The initiation of this project allowed monitoring to continue until the new change planned for the catchment, i.e., the clear felling of *Acacia mearnsii* and subsequent replanting with a *Eucalyptus* species. This will allow for the pressing questions surrounding genus exchange issues to be addressed with empirical research.

R600 000
2017

Programme 2: Surface water / groundwater hydrology

Development of a National Groundwater Strategy

Private Consultant

1117

South African, as well as world-wide, experience has been that management of the open access, local resource, groundwater, is complex and the evolution of appropriate groundwater management systems is a long-term process. The way forward has been captured in a groundwater governance framework, broken down into a number of strategy themes and strategic actions in which every stakeholder can now recognize the overall needs as well as his own objectives and his own areas of influence for action. This document represents the first edition of a National Groundwater Strategy, following widespread consultation during 2016 among stakeholders in the water and related sectors. During the consultation, the sustainable development vision for the resource and the principle of 'local management facilitated nationally' was strongly endorsed.

R200 000
2015-2016

Programme 4: Climate change and water resources

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

South African Weather Service

2247

While numerous studies covering South Africa have previously been completed on assessments of likely changes in rainfall and temperature as a result of global warming, studies on the possible impact of these meteorological variables on sector-specific indicators are not as frequent. It was therefore not the purpose of this study to repeat and duplicate work already conducted. This study provides additional information with a specific emphasis on the likelihood of changes in the future frequency occurrences of extreme dry and wet spells. This report addresses the need of frequent updates on likely catchment discharge changes, focusing on streamflow projections in the extreme minima and maxima ranges of streamflow.

R1 113 000
2013–2017

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

South African Weather Service; University College London, Gobabeb Training and Research Centre, Desert Research Foundation; CSIR; University of KwaZulu-Natal (Pietermaritzburg); University of Limpopo; Department of Rural Development and Land Affairs; Koninklijk Nederlands Meteorologisch Instituut

2309

There is an ongoing unprecedented research interest in land-atmosphere interactions among the diverse fields of the scientific community. This could be attributed to the role this particular field plays in climate science and global change in general. In this regard, many publications have pointed out the existence of a strong interaction between land surface characteristics and the atmosphere processes predisposing climate change and variability. There is an understanding in the earth system science community that climate change is expected to affect means and variability of several climate variables, wherein soil moisture (SM) is a key variable in the climate system as it is directly affected by global warming, with consequences for the hydrological and energy cycles. As an important variable of the land-climate system, understanding the interaction of SM and the key climate variables such as precipitation (P) and temperature (T) remain a pertinent and hot topic in climate research due to the nature of the feedback mechanism characteristic of the climate components.

R1 080 000
2014-2017

Managing limits in skill for seasonal climate forecasting

University of Cape Town; Pegram and Associates (Pty) Ltd

2249

Seasonal forecasts for southern Africa have for many years been provided by national, regional and international efforts and are usually presented as large-scale maps associated with some measure of probabilities. At the level of international research, developments in modelling and the use of model ensembles has continued to evolve, including, for example, in dynamical and statistical downscaling, linking to hydrological and crop forecasting or in diversifying the approaches adopted. In particular, the recent decade saw a transition of operational forecasts from atmospheric models to those based on fully coupled atmosphere-ocean global circulation models, both internationally and locally. As a result of those developments, in some cases 'significant' skill advances have been achieved with respect to specific physical processes, yet the reliability of these forecasts remain cast in a perspective of 'is the forecast reliable in differentiating from climatology at some large spatial scale?'

R2 025 640
2013-2017

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

University of the Western Cape; ARC Institute for Soil, Climate & Water; University of Limpopo

2314

Those who live in remote rural settings remain largely absent from the climate change related decision-making processes and in particular the voices of women, who are affected by climate change, have not yet been adequately captured. The language of climate change is highly technical and policy makers, researchers, development practitioners and planners claim to represent the voices of the poor but all too often use a language that is likely to be inaccessible to those communities who are most vulnerable to these changes. Importantly, the linkages between environmental degradation (due to climate change) and human security require more concrete examples to better understand the pathways and effects of vulnerability and resilience. Women's experiences and voices are key to such an enriched understanding. For this reason, the study proposed to capture the narratives and voices of relatively impoverished rural women and in so doing to bring the wisdom, experience and concerns of women facing the effects of climate change in their everyday life, to the fore.

R1 200 000
2014-2017

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

University of Cape Town; South African Weather Service; CSIR

2317

Drought is a natural hazard with severe socio-economic impacts in many Southern African countries. It is a threat to water management, water-dependent activities, and livelihoods in Southern Africa. Impacts of drought are usually severe in communities where the socio-economic activities of the people depend of availability of water in surface and sub-surface sources. Of particular concern are regionally extensive droughts, which produce widespread impacts that cannot be compensated by redistribution of water, food and energy production from other parts of a resource system. Drought can have transnational and multifaceted impacts. In 1991 and 1992, a drought depleted groundwater reservoirs, reduced freshwater availability, and forced people to use water from unprotected sources; as a result, many people suffered from cholera, diarrhoea and dysentery and more than 90% of small inland dams in the eastern part of Southern Africa dried up. The drought was also associated with widespread food shortages across the affected region. With more than 60% of Southern Africa vulnerable to drought, changes in characteristics (e.g. frequency, intensity, duration and spatial extent) of large drought events would have serious consequences for regional water, food and energy security. The focus of previous studies on droughts has largely been within South Africa (e.g. Rouault and Richard, 2003), with a minimal exploration of the coherence of regionally extensive droughts (REDs) in Southern Africa. Meanwhile, the devastating impacts of REDs in 1991 and 1992 call for better understanding of the spatial and temporal characteristics of REDs. This project squarely addresses this need.

R1 150 000
2014-2017

EXSMET: EXporting PyTOPKAPI and HYLARSMET over SADC including RSA with EXtended spatial and computational capacity of Soil Moisture and EvapoTranspiration for flood and drought monitoring

Pegram and Associates (Pty) Ltd; University of Cape Town; Department of Water and Sanitation; South African Weather Service; University of KwaZulu-Natal (Westville)

2312

Timeous and routine monitoring of the spatial distribution of soil moisture and evapotranspiration over a large region in fine detail has great value for coping with two weather extremes: flash floods and droughts. The current state of soil moisture conditions has a major impact on the runoff response of a catchment to heavy rainfall; monitoring the wetness of the soil in detail over large regions, without having to laboriously take expensive samples, is a bonus for agricultural managers who need to understand the status of crop growth potential. This is particularly relevant in the southern and central African countries in the SADC region which contribute importantly to the food basket of Africa. This research had two thrusts. Firstly, it extends the coverage of near real-time soil moisture (SM) and evapotranspiration (ET) monitoring over the SADC region using the existing methodology of operating the PyTOPKAPI hydrological model in Land

Surface Modelling mode (WRC Report No. 2024/1/12). Secondly, this research develops powerful computing techniques that will make it feasible to drive the modelling procedure for the vastly increased number of cells required to cover the SADC region. The same techniques can be applied to improve the spatial detail of distributed hydrological modelling at fine scale in RSA (as piloted in the WRC Report No. 2024/1/12) to complement the SAFFG initiative undertaken in WRC Report 2068/1/15. The improved computational speed will also add convenience when performing ensemble simulations to assess the impacts of climate change scenarios on hydrological variables at fine scale.

R1 980 000
2014-2018

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Pilot study and technology transfer of the Integrated Water Quality Management System (IWQMS) in the Breede-Gouritz 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

The aim of this project was to pilot the Integrated Water Quality Management System (IWQMS) that was developed in WRC Project K5/ 2159, by introducing the proposed decision support system to an existing institution, to undertake a literature review on early warning systems and propose how the various options could be incorporated into the IWQMS. The benefits of such a system are: close to real-time water quality/ quantity reporting by the water users; close to real-time access to water quality/quantity monitoring information; simplified reporting for the regulators; potential to include civil society organisation in the input of water quality data; and the potential for spreading the monitoring footprint and reducing the cost of monitoring to the regulator. The results have indicated a number of institutional constraints, as well as some exciting possibilities. The concept of ownership seems to be a large hurdle that will need to be removed. It is going to take a mind-set change to get personnel at all levels out of their comfort zone as the immediate reporting may put them in the spotlight, where questions may be asked and answers will need to be given. It will mean that officials and water users at all levels will need to be proactive rather than reactive, and will need to work as partners in implementing integrated water resources management. The project has had some positive outcomes in that it will be used by the Breede-Gouritz Catchment Management Agency, with potential for use in the Olifants WMA as part of the development of an Integrated Water Quality Management Plan for that area, and potentially in the Inkomati-Usuthu WMA.

R1 500 000
2015-2017

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

University of Pretoria; CSIR; Department of Water and Sanitation

2438

Emerging chemical pollutants (ECPs) may be defined as chemicals which do not have a regulatory status, but which may have an adverse effect on human health and the environment. Data relating to the occurrence of ECPs in South African waters is currently very limited, which can be ascribed in part to the high cost of performing the complex analyses involved. This project aimed to address this shortcoming by developing novel quantum dot (QD) based fluorescence sensors for target ECPs of relevance to South Africa. ECPs covering a range of compound classes were selected as target analytes after prioritising over 150 compounds. Specifically, compounds which were known to have environmental and human health concerns and/or are known to be used or produced in large quantities and are ubiquitous in the environment were selected, namely, polycyclic aromatic hydrocarbons (as a compound class); atrazine (a pesticide); acetaminophen (a pharmaceutical) and triclosan (a personal care product). Two types of QDs, namely semi-conductor CdSe/ZnS QDs and graphene QDs, were synthesised, characterised and then evaluated as fluorescence sensors of target ECPs in water. Environmentally appropriate limits of detection were achieved and these novel fluorescence sensors were shown to have the potential to provide complementary information to standard analytical approaches and may thus enable wider monitoring of target ECP contamination in South African water in a cost-effective manner. The sensors may also find application in determining the effectiveness of wastewater treatment processes in the removal of ECPs. It is thus envisaged that, after further optimisation, these sensors will assist in enhancing the sound management of our water resources.

R438 600
2015-2016

Geophysical delineation and monitoring of AMD in COH

CSIR; Tshwane University of Technology

2440

The main aim of the project was to assess the applicability of the time-lapse electrical resistance tomography (ERT) survey method to monitor changes in local aquifer contamination levels (sulphate content). For this project, geophysical test sites were selected around the perimeter of the inferred AMD footprint that covered a range of pollution scenarios, ranging from highly polluted to virtually contaminant-free. The objective comprised the following two parts:

- To characterise and quantify the electrical resistivity of the dolomitic aquifer and consequently to establish baseline geophysical ‘snapshots’ for these test sites
- To revisit these sites after approximately 12 months and repeat the resistivity surveys

Transient changes in the groundwater quality – in particular the sulphate concentration – were expected to manifest as corresponding changes in the baseline resistivity responses. If these changes in resistivity responses could be reliably correlated with the changes in water quality, it would indicate that time-lapse

resistivity surveys could be employed to supplement the ongoing borehole-based groundwater monitoring programme. Ongoing geophysical monitoring efforts could help to improve the lateral accuracy of the AMD footprint delineation, obviating the need to add significantly to the existing network of monitoring boreholes. For the cases where the data enabled a meaningful time-lapse analysis, it was found that the observed changes in the background aquifer resistivity were very small (near-zero) and it is inferred that the actual changes in aquifer resistivity over the period between Year 1 and Year 2 were likely too subtle to manifest as prominent anomalies on the difference images. There were, however, some promising indications, particularly at Crisuel Farm, that transient changes in aquifer sulphate levels could be detected using time-lapse ERT measurements. Although the overall results in this research project do not serve to clearly justify the routine use of the time-lapse ERT method in the COH area, there were sufficient promising indications and lessons learnt to suggest that the approach is a reasonable option in terms of providing supplementary information for traditional borehole sampling approaches.

R720 240
2015-2017

Multi-array sensor technology for polycyclic aromatic hydrocarbons screening in wastewater
University of the Western Cape; City of Cape Town Metropolitan Municipality
2454

PAHs are highly hydrophobic species that are readily absorbed from the gastrointestinal tract of humans and other mammals, where they particularly deposit in the fatty tissue. Cytochrome P450-mediated mixed function oxidase systems are primarily responsible for oxidation or hydroxylation of these PAHs. Whilst there are numerous well-known natural and anthropogenic sources of PAHs it is perhaps less well known that PAHs can be produced biologically by certain plants and bacteria or formed during the degradation of plant material. Polycyclic aromatic hydrocarbons are not the easiest analyte species to detect based on redox chemistry. Chemical oxidation appears to be a minor PAH degradation mechanism under most environmental conditions, directly affected by molecular weight and structure of the compound, its physical state, temperature, and the strength of the oxidizing agent. The novel polymer electrocatalysts developed in this work provided for a wide range of new catalysts to be implemented in a controlled electrocatalytic approach. Unlike total degradation that may be achieved by high voltage electrolysis, electrocatalysis seeks to identify unique signals for identification of analyte species and intermediates that may be used for quantification and the understanding of degradation mechanisms. The electrocatalysts were developed from Schiff base monomers synthesised by aldol condensation chemistry to produce reliable product in good yield. These polymers were then deposited in situ at commercial screenprinted electrode arrays to evaluate and quantify the oxidation current generated by electrochemical oxidation of selected PAH species. For the first time, in this project we have reported on the electrochemical redox signals reported at commercial screenprinted carbon electrodes and novel polymer-coated electrodes, of a wide range of the most significant PAHs, in a comprehensive manner. Both the material aspects of the actuator type polymers as well as the electrochemical signal reporting of PAHs, listed by the US EPA as priority pollutants, are completely novel aspects of the research

concluded. The novel electrocatalysts were then assembled in a multi-array configuration as a pre-text to the development of a fully independent electro-analytical tool for discrimination and quantification of PAHs in mixed samples. An enhancement of electrochemical transduction may be effected by incorporating a suitable electron wiring effect by doping the polymers with metal nanoparticles or other high surface area nanomaterials. Any development to improve the electrochemistry of the materials will directly benefit the overall analytical protocol developed here. However, the systematic approach demonstrated in this work is groundbreaking and paves the way for all future developments in this regard.

R730 000
2015-2017

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

Rhodes University

2782

The study has led to a refined ToR for the upper Vaal which will look at the following: The main objective of this project is to undertake a case study in the Vaal Barrage area and associated rivers' catchments: UJ (Taaibosspruit), UI (Klip River, Gauteng), Suikerbosrant River, Rietspruit, Leeuspruit and Blesbokspruit, within the lower section of the upper Vaal River catchment to link source-directed controls (SDCs), like the setting of water quality licence conditions, to resource quality objectives (RQOs) and/or site-specific conditions, in a way that water quality discharge specifications are clarified for better management of water resources. The specific objectives are:

- Undertake a comprehensive and thorough assessment of existing practices, data, approaches, methods, and tools including relevant catchment literature, with regard to source-directed controls (SDCs) and resource quality objectives (RQOs) in the proposed study areas
- Develop an appropriate robust and scientifically defensible but flexible method/tool/decision support system (DSS) (e.g. a mass balance model) for transparently setting water quality license conditions (point and diffuse) taking account of receiving resource quality objectives/site-specific conditions
- Demonstrate and test the implementation and applicability of the developed method/tool/DSS under multiple water quality, site-specific/RQO scenarios (i.e. scenario analysis) with catchment stakeholders including the relevant units within the Department of Water and Sanitation, catchment management forums and water users, e.g., Sasol, Eskom, Rand Water, local government
- Communicate widely with catchment stakeholders and build capacity of the relevant units/sections within the Department of Water and Sanitation, and water users through training on the use and application of the developed framework and method/tool/DSS. The ToR has been accepted by the main partners, DWS and Sasol.

R100 000
2017

Programme 2: Water quality modelling

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

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

2328

The pollutant transport processes in a river depend upon the mixing mechanisms as well as physical, chemical and biological properties of the pollutants. Study of pollutant transport in a river is vital to correctly evaluate the pollution threat at downstream locations and for regulating pollutant disposal, so that the ecosystem remains safe from any incoming pollution threat. Water quality models are tools for simulating the fate of pollutants in river water, and use mathematical equations to simulate pollutants along the river. The advection dispersion equation (ADE) model is a well-known solute transport model which is described by a second-order partial differential equation. Over the past three decades, as an alternative to the ADE model, a number of conceptual models have been developed and applied successfully with selected conditions for simulating solute transport. Pollutant loadings in rivers have increased drastically, requiring continuously developing and improving existing water quality models to predict water quality monitoring data. Thus, this project aimed at further developing the Hybrid Cell in Series (HCIS) model for selected water quality parameters (NH_3, NO_2 and NO_3), as this model was successful in simulating BOD, COD and DO water quality parameters in the past. In this project, the uMngeni River reaches between Midmar Dam and Mortons Drift and along uMsunduzi River at Baynespruit confluence were considered. All required data were collected for the year 2014 and the model was applied for the selected study reaches. It was noted from the simulation results that the general trend of observed and simulated data were matching for the period January to March and July to December 2014 at all sampling locations. The model under-predicted the nutrient concentrations during the period May and June 2014 and it was noted from the rainfall data that the catchment flush during the rainy period might have resulted in higher instream nutrient concentration. This project concludes that the model is reasonably capable of simulating spatial and temporal nutrient pollutant concentrations under limited conditions such as steady-state flow and assuming a reachwise uniform channel and for a non-rainy low-flow period.

R667 000
2014-2017

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

University of Johannesburg

2321

This project describes modelling and analytical methods for monitoring specific organic and inorganic pollutants in selected South African water systems. It involved modification of the existing geochemical databases to incorporate five chlorinated organic compounds (COCs) and using this hybrid database in geochemical modelling, metal speciation, calculation of saturation indices and solubility products. The results indicated that there are substantial levels of inorganic and organic

pollutants present in these water systems. Based on this data, a geochemical model for predicting/simulating metal speciation, solubility and saturation indices, bioavailability as well as fate and transport was developed. An android-based mobile application was developed to be used by all people involved in the water sector for immediate on-site analysis. The application is designed to be used in the field for instant results.

R665 000
2014-2017

Programme 3: Impacts on and of water quality

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

Cape Peninsula University of Technology; Breede-Gouritz Catchment Management Agency; UNESCO-IHE; University of Twente

2329

The management of the combined effect of urbanisation, industrialisation and population growth on water resources is a challenging task and the increasing demands for water for different uses require a broad range of water management strategies and tools. An integrated approach is therefore needed to obtain the knowledge on the involved hydrological and biochemical processes within a catchment in order to manage this combined effect. This research therefore focused on developing a generic risk assessment framework of river pollution in the Overberg West sub-catchment of the Breede-Gouritz Water Management Area (BWMA). The framework covers pollutant source/s, identification and type/s, pollutant transport modelling, hazard estimation, exposure assessment, risk mapping and risk management. The purpose is to integrate data and information, resulting from this integrated risk assessment, into the decision-making structures of the Breede-Gouritz Catchment Management Agency (BGCMA) and other relevant authorities. It is envisaged that the outcomes of this research will be used to aid the regulatory function of water resource quality monitoring and reporting.

R850 000
2014-2017

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

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

Groundwater abstraction from the shallow aquifer system has increased significantly in recent years. Where the rate of groundwater abstraction has

exceeded the rate of groundwater recharge, this has resulted in the over-exploitation of some of the shallow aquifer systems. These aquifer systems have effectively been mined for their water reserves. The dewatering of the aquifers has resulted in the lowering of the groundwater table, and possibly the closure of certain water-bearing fractures due to the reduction of water pressure in the fracture networks. Boreholes used for groundwater supply are usually shallow (< 100 m), although deeper abstraction boreholes do occur. However, groundwater abstraction from aquifers that occur at depths greater than 300 m is very rare in South Africa. For this reason, not much is known about the deep aquifer systems and their potential to provide water. It is known that aquifers occur at depths much greater than 300 m. Many of these aquifers appear to be high-yielding, although the salinity of the groundwater in the aquifers generally increases with depth. These deep aquifers may be considered as potential groundwater resources, to be used when the surface water sources and shallow groundwater sources are unable to meet the demands of the water users in an area. The deep aquifer systems may thus contribute to the water security of South Africa. This research project aimed to collate all the available information on the deep groundwater system and to provide an overview of the current state of knowledge on the deep aquifers of the country. From a study of the available information, a preliminary characterisation of the deep aquifer systems may be done while gaps in our understanding of the deep geohydrology may be identified. To assess the potential for deep exploitable aquifer systems within the different geological formations of South Africa, a ranking system was used in which the formations were rated according to their likelihood of hosting, or being associated with, deep aquifers. Formations with Rank 1 were considered to show positive indications for the presence of deep aquifer systems, while formations with Rank 2 were considered to show some indications of deep groundwater. Ranks 3 and 4 were assigned to those formations that show neutral or negative indications for deep aquifers.

R1 000 000
2015-2017

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

The project produced a training manual that can be used for capacitating municipal officials, technicians, managers, and decision-makers, as well as communities where villages and towns are partially or solely reliant on groundwater resources. Efforts should be made in order to ensure that the document is accredited and that a strategy for the rollout of the training is developed. It is of utmost importance that officials at municipalities, in particular, have access to training on groundwater resource management and groundwater governance. The training manual should not be regarded as a technical document, but rather as a basic document intended for trainees from on-the-ground level to management level.

R500 000
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 tool is available in two forms, web-based and in Excel format, and is accessible on the RiskQ website (www.riskq.co.za). The products from this project include: (i) A web-based mine-water management vulnerability assessment tool (where an Excel-based tool will also be accessible), (ii) a guideline document on how to use the mine-water management vulnerability assessment tool, and (iii) a research report explaining the tool's development and design. The purpose of the mine-water management vulnerability assessment tool is to guide the mining sector in self-assessment to assist with improved mine-water management and associated resource protection. In addition, the tool seeks to support the development of strategies and timely action plans relating to measures that should be put in place to address mine-water management challenges. The tool therefore aims to assist mines and stakeholders to identify critical areas requiring attention. It takes into consideration water management for three phases of mining: new mines, operating mines, closing mines. The approach used to develop the mine-water vulnerability assessment tool was to utilise the existing regulations, policies and guideline documents and licence requirements as a basis and engage in consultation with mining companies and their associations. Considerations from key stakeholder requirements and practices from elsewhere, found in the literature, were also made. This means the areas of assessment have looked beyond just water management and include all areas that may have an effect on water management.

R854 160
2015-2017

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

Umvoto Africa (Pty) Ltd

2532

Water plays a significant role in the economies of the agricultural, business and industrial sectors. Expanding populations, economies and climate change have put pressure on the quality and availability of water resources in South Africa, therefore water resource protection becomes increasingly important for sustainable water supply management. Hence, a review of the state-of-the-art of water resource protection in South Africa has been undertaken. Gaps in scientific understanding and implementation with regards to water resource protection have been identified through literature review and discussions with stakeholders and experts. Aiming to improve the water resource protection in South Africa, a research strategy has been developed to tackle the most relevant of the identified gaps. The objective and strategic intent of follow-up research studies is to build knowledge for enabling water resource protection through integrated catchment management that supports adaptation to climate and socio-economic change. The gaps identified and their causes were turned into research questions and prioritised according to the following criteria:

- Possible short-term gain by changing implementation (pillar society)

- Possible medium-term gain by reviewing and updating legislation/regulations (pillar legislation)
- Initiating a structured, longer-term programme to build knowledge (pillar science)

The following five (5) research studies or programmes have been prioritised:

- Audit of the current status of RDM and SDC implementation and enforcement
- Establishment of 'model catchments' on a sub-catchment and catchment scale
- Awareness campaigns and training programmes for social behaviour changes
- Roll-out of cooperative governance framework ensuring cooperative governance across all sectors and all tiers of government, and enabling enforcement of compliance with rules and permits
- Review and update of existing tools and best practice guidelines

R400 000
2016-2017

Programme 2: Land-water linkages

Unconventional gas exploration and mining and its impact on South Africa's water resources
SLR Consulting (SA) (Pty) Ltd Prime Africa Consultants cc; University of the Western Cape
2322

This report presents best practices to prevent and mitigate risk to water resources from shale gas development and effective regulation of unconventional gas development. The report is based on a number of international site visits to draw on the experience of other jurisdictions and its policymakers, industry experts and environmental regulators with regard to dealing with water issues associated with unconventional gas production. Although the report focuses on shale gas the recommendations are transferable to coalbed methane (CBM) and underground coal gasification (UCG) exploitation. Regulation is necessary to ensure consistent data collection, normalise best practices, and provide a level playing field, and should e ectively drive the industry to achieve desired outcomes of environmental protection. The report is in 6 parts:

- Primer: Unconventional gas exploration and production in South Africa: Understanding the water-related implications
- Best practice guidance and regulatory responses to mitigate the impact of shale gas development on South Africa water resources
- Evaluating risks to groundwater resources from the proposed shale gas operations in the Karoo basin, South Africa
- The quest for groundwater monitoring and early warning systems in the context of shale gas development in South Africa
- An analysis of the challenges for groundwater governance during shale gas development in South Africa
- Water Science Plan for Unconventional Gas Exploration and Production

R2 740 000
2014-2017

CURRENT PROJECTS

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.

R 1 162 600
2013–2016

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

R700 000
2016–2018

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

R1 788 000
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 the water tables and water accounts in Excel to enable ease of use for integrated impact and policy analysis

R1 800 000
2015–2017

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

R400 000
2015–2017

Programme 2: Surface water / groundwater hydrology

Sustainability of shallow groundwater utilization for smallholder 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

R2 727 800
2015–2018

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

R3 500 000
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

R2 500 000
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

R1 700 000
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

R1 400 000
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

R1 605 960
2015–2018

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

R380 000
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

R900 000
2016–2018

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

R270 000
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)

R1 500 000
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)

R760 000
2016–2018

Programme 4: Climate change and water resources

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

R600 000
2014–2016

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

R1 540 000
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

R1 271 360
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

R1 257 000
2015–2018

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

R719 800
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.

R754 491
2016–2019

Programme 5: New water and water security

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

R1 400 000
2014–2017

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

R2 000 000
2015–2018

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

R2 000 000
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

R780 000
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

R3 000 000
2015–2018

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

R1 037 000
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

R1 635 000
2016–2019

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, NH_3, NO_y and S_xO_y species, in and above ground and in seawater

R300 000
2016–2018

Programme 2: Water quality modelling

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

R1 260 000
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

R898 737
2015–2018

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

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

R1 000 000
2012–2015

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

R430 500
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

R1 000 000
2016–2019

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

R1 000 000
2016–2019

Programme 2: Land-water linkages

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

R1 000 000
2015–2018

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

R2 160 000
2016–2019

NEW PROJECTS

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The hydrogeology of Groundwater Region 41: Western Great Karoo

Geowater IQ (Pty) Ltd; Jeffares & Green (Pty) Ltd

2742

Aims:

- Analyse and present the related groundwater data in a concise manner
- Estimate how much water 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

R270 000
2017-2018

Geo-statistical analysis and sub-delineation of all Vegter regions

North-West University (Potchefstroom)

2745

Aims:

- Use existing borehole databases (NGA, GRIP) to perform the geo-statistical analysis as prescribed by the Vegter methodology (Vegter, 2001)
- Use the geo-statistical analysis and delineate sub-Vegter regions which have a similar geohydrological character
- Deliver a national baseline dataset based on the geo-statistical analysis and delineation
- Deliver a software tool to manipulate and augment the baseline dataset to ensure a dynamic dataset that can always be updated
- Documentation to describe the production of the dataset as well as an instruction manual to operate the accompanying data analysis tool

R400 000
2017-2019

Programme 2: Surface water / groundwater hydrology

The development of an integrated (early warning) system for adaptation and mitigation to hydrological drought in South Africa

IWR Water Resource (Pty) Ltd; Inkomati-Usuthu Catchment Management Agency; Institute for Water Research, Rhodes University; University of Cape Town

2746

Aims:

- Identify primary sources of hydrological (streamflow and groundwater) predictability and their relative influence on seasonal and annual hydrological predictability
- Develop a hydrological monitoring system that provides consistent and reliable national information on daily or weekly time scales
- Identify and develop hydrological drought indicators and thresholds for major dams, rivers and aquifers for different drought phases, and link these to the early warning system
- Develop an operational integrated early warning (real-time or near real-time) system for hydrological drought monitoring and prediction

R2 500 000
2017-2020

Design flood estimation in urban areas in South Africa

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

2747

Aims:

- To improve the understanding of hydrological processes in the South African urban and sub-urban environments
- To develop a calibrated design flood estimation method for urban and sub-urban areas, either by updating existing methods with new data, or developing a new method, by focusing on two case studies in urbanised areas of South Africa
- To disseminate any new-found knowledge through scientific papers and at conferences

R700 000
2017-2019

The expansion of knowledge on evapotranspiration and stream flow reduction of different clones/hybrids to improve the water use estimation of SFRA species (i.e. *Pinus, Eucalyptus*, and wattle species)

University of KwaZulu-Natal (Pietermaritzburg); Institute for Commercial Forestry Research; SAEON; Mondi

2791

Aims:

- To expand the knowledge of the estimates of water use of different clones and hybrids of eucalypt, wattle and pine species (e.g. clones/hybrids most commonly used, clones/hybrids planted in optimal sites)
- To expand the knowledge on the water use of different stand densities
- To address shortcomings in the availability of leaf area index information for different SFRA species, clones and hybrids
- To improve existing tools used for the estimation of the impacts of SFRA through the inclusion of improved soils data and baseline land cover data, as well as the inclusion of the latest process results related to water use (i.e. evapotranspiration) of SFRA clones, hybrids and species

R3 500 000
2018-2021

Quantification of the evapotranspiration and stream flow reduction caused by bamboo species on water resources in South Africa

Aquamet; University of KwaZulu-Natal (Pietermaritzburg); University of Pretoria; NBASA

2792

The objective of this study is to quantify the evapotranspiration and stream-flow reduction impacts of bamboo species on water resources in South Africa and to assess the feasibility of declaring bamboo as a SFRA. Specific aims are:

- To determine the evapotranspiration and the stream flow reduction impact of bamboo species
- Extrapolate the evapotranspiration/ SFR results to catchments suitable for bamboo production
- To assess the viability of declaring bamboo species a SFRA from a water resource perspective

R2 500 000
2018-2020

Programme 3: Water resource planning and infrastructure

The state of water research in the African continent

Quantitative Evidence Research Consultancy Services cc

2743

Aims:

- To identify the quantum and quality of water research in the 34 African countries including trends over time and rankings
- Identify areas of water research strengths and weaknesses in each country
- Map collaborative patterns among countries and regions
- Identify centres of expertise, research emphasis and prolific researchers in the various countries
- Identify funders of research as revealed in the various publications
- Identify water-related patents awarded by USPTO in the various African countries
- Inform policy and decision makers about the state of water R&D in the continent

R300 000
2017-2018

Towards the sustainable exploitation of groundwater resources along the west coast of South Africa

CSIR; Department of Water and Sanitation (Western Cape); University of the Western Cape

2744

Aims:

- To confirm the hydrogeological characteristics and dynamics of the Langebaan Road Aquifer System (LRAS) and the Elandsfontein Aquifer System (EAS)
- To determine the natural recharge areas of the aquifer units
- To investigate the potential for implementation of a managed aquifer recharge (MAR) scheme for additional storage of water, as well as the best possible MAR method to be used in this area
- To develop a management plan for the LRAS and EAS, which considers the implementation of a MAR scheme
- To design an optimized monitoring network for the aquifer systems

R2 000 000
2017-2021

Development and assessment of a probabilistic rational method for South Africa

University of KwaZulu-Natal (Pietermaritzburg)

2748

Aims:

- Collation and quality control of selected gauged flow data in South Africa
- Produce at-site flood frequency curves for selected stations
- Compilation of catchment characteristics database
- Identify and verify homogeneous flood-producing regions
- Calibration of the Rational Method within homogeneous regions
- Regional flood model development using regression analysis
- Assessment of the performance of the proposed methodology
- Develop a design flood estimation utility for application of the newly proposed methodologies by design practitioners

R1 000 000
2017-2019

Design of sustainable river abstractions/diversion works for potable water use, irrigation and hydropower generation in South Africa – revised guidelines

Stellenbosch University

2750

Aims:

- Review the performance of river abstraction/ diversion works in the field which were designed based on the 2006 WRC guidelines and revise/ improve the hydraulic design guidelines as required
- Develop design guidelines for sand trap/settler/ cyclone/hoppers with jet pumps for SA conditions with high loads of fine cohesive sediments, considering lessons learned from case studies in the field
- Propose minimum hydraulic design guidelines for very small river abstraction works, i.e., < 100 L/s for sustainable operation with low maintenance
- Propose sediment control measures at intakes of run-off river hydropower schemes

R1 443 233
2017-2020

Quantifying rainfall using rain gauges, radar and satellite

North-West University (Potchefstroom); National Centre for Atmospheric Research

2751

Aims:

- Capacity building in quantitative precipitation estimation and weather radar to ensure sustainability of precipitation monitoring infrastructure in South Africa
- High-resolution real-time weather radar, tipping bucket rain gauges, disdrometer and general weather data for the Mooi River catchment accessible by the research community
- Developing local, affordable weather stations for use in community rainfall observation network
- Communicating precipitation observations to interested communities using appropriate platforms

R800 000
2017-2018

Programme 4: Climate change and water resources

The development of a preliminary approaches to sediment site evaluation and associated risk

Golder Associates Research Laboratory; University of Johannesburg;

2754

Aims:

- To conduct a comprehensive literature survey of available internationally applied sediment collection and analysis procedures
- To select and standardise the methods to assess the risk of potentially contaminated sediment
- To collect sediment data over one hydrological year in order to generate data to standardise approach
- To select and standardise the minimum sediment sampling requirements to assess risk
- To develop a preliminary tiered approach for the collection and assessment of sediment
- Consultation with stakeholders (DWS, RQIS and management agencies), consultants and relevant students to ensure capacity development and knowledge uptake

R1 500 000
2017-2019

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

University of Pretoria; Department of Water and Sanitation

2752

Aims:

- To investigate the effects of various parameters, such as pH and contact time, on the fluorescence sensing of the selected ECPs
- To determine the effects of potential interfering compounds on the selectivity and fluorescence sensing capability of the QD sensors
- To develop methods to functionalise the QD materials via MIP overcoating and QD doping and to investigate the impact thereof on the selectivity of the fluorescence sensors towards the target ECPs
- To optimize the methodology to immobilize the QDs in siloxane polymers in order to generate solid fluorescence sensor prototypes
- To test and optimize the fluorescence sensor prototypes for the target compounds in real water samples (tap water and river water)

R800 000
2017-2019

Programme 3: Impacts on and of water quality

Water quality offsetting

Eon Consulting; Sasol Technology (Pty) Ltd

2753

Aims:

- Provide a literature overview of the water quality offsetting processes in relevant countries such as the United States, Australia, the Netherlands, Canada and New Zealand
- Develop a methodology suitable for the South African water regulatory landscape
- Quantify the offsetting requirements of the future water quality limits of the water use licence of Sasol Secunda
- Create a catchment profile of the Waterval catchment in which Sasol operates
- Compile a pollution inventory and pollution potential map based on the catchment profile and the offsetting requirements of Sasol Secunda
- Identify candidate offsetting sites
- Assess the offsetting opportunities of the selected candidate sites
- Quantify time and cost of offsetting interventions
- Compile a policy guideline based on scientific principles for the implementation of water quality offsetting in SA

R600 000
2017-2020

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Integrated catchment management: From source to receptor

Nxt2U (Pty) Ltd; University of Pretoria Consortium; CSIR; Department of Water and Sanitation; Rand Water

2740

Aims:

- To develop a model catchment that will enable the formulation of a living integrated catchment management strategy
- To develop an approach that incorporates both land management and water management to ensure resource protection and sustainable utilisation
- To develop a model catchment, using a priority catchment in South Africa, to develop appropriate tools and strategies to effectively manage catchments at a variety of scales

R2 000 000
2017-2020

Urban groundwater development and management

Delta-H (Pty) Ltd; University of Pretoria; Mills Water

2741

Aims:

- Assess the current state-of-the-art and gaps on groundwater resources in urban areas in terms of groundwater demand, groundwater use, groundwater levels, and groundwater quality
- Develop and suggest a research strategy for developing and managing urban groundwater resources
- Suggest policy requirements that can deliver a holistic resource protection at all government spheres, departments, agencies, industries and communities
- Suggest high-level innovative technical solutions for groundwater use in urban areas

R1 000 000
2017-2019

Programme 2: Land-water linkages

Climate change impacts on the safety of dams in South Africa

University of Cape Town; Department of Water and Sanitation

2749

Aims:

- Identify South African climate change scenarios that would impact dam safety
- Identify dam failure modes that are influenced by climate change
- Predict the structural behaviour of concrete dams using climate change models
- Evaluate the effect of climate change on structural performance

R1 500 000
2017-2020

Hydrological modelling of climate change impacts for development of adaptation strategies: The case of Luvuvhu River Catchment, Limpopo, South Africa

University of Venda

2771

The purpose of the study is to investigate the impact of future climate change scenarios on water availability for agricultural and municipal/domestic water uses and develop practical adaptation options for vulnerable communities in Luvuvhu River Catchment. The specific objectives are:

- To predict the effect of future climate change scenarios on water resource availability for agricultural production and domestic/municipal water uses in the catchment
- To identify and assess adaptation measures for climate change used by communities in the catchment
- To develop practical adaptation options for future climate change scenarios in consultation with key stakeholders

R1 200 000
2017-2020

CONTACT PERSONS

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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 groundwater).

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

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

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

OBJECTIVES

The strategic objectives of KSA 2 are as follows:

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

THRUSTS AND PROGRAMMES

Please note: This list reflects the Thrusts and Programmes for KSA1 for 2017/18. Going forward, KSA 1 and 2 now form a new KSA: Water Resources and Ecosystems, with new Thrusts and Programmes.

THRUST 1: ECOSYSTEM PROCESSES

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

Programme 1: **River, wetland, groundwater and dam processes**	**Scope:** Programmes to investigate the ecosystem functioning, structure and processes of riparian zones, rivers and impoundments will be developed. This is an area in which South Africa needs improved capability to manage and, in the case of riparian zones, is a topic attracting international interest.
Programme 2: **Estuarine, coastal and marine processes**	**Scope:** Estuarine, coastal and marine systems are fragile, while they are highly productive ecosystems and are highly sought after as places to live and establish various enterprises. Catchment activities and land uses affect terrestrial water resources and ultimately the estuarine environment, while marine water conditions also have an impact on the estuarine environment and ecosystems. Projects in this programme will generate knowledge about the ecological processes, structure, and functions of ecosystems of these systems. The programme will also address the impact of land uses and marine conditions on ecological processes in the estuarine and coastal environment.

Programme 3: **Aquatic, riparian and land connectivity**	**Scope:** Research will be conducted to develop understanding of the interconnections among various ecosystems and ecological processes and functions of water resources, terrestrial systems (soil, air and vegetation) and to assess their value to both the catchment and people.
Programme 4: **Surface and groundwater interactions**	**Scope:** Within this programme, the dynamics of groundwater-dependent ecosystems will be investigated in relation to the aquifers on which they depend. This will be related to exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.

THRUST 2: ECOSYSTEM MANAGEMENT

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

Programme 1: **Ecological Reserve**	**Scope:** Research in this programme will be conducted to develop and refine methods for determining and operationalizing the ecological Reserve as required by the NWA. The programme will address the more strategic issues, such as the development of new and improved methods, as well as the shorter-term issues, such as implementation of the Reserve. This programme is managed in close association with DWA.
Programme 2: **Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems**	**Scope:** Within this programme research will be conducted to develop an understanding of the effect of anthropogenic disturbance on aquatic ecosystems in various water resources. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage water resources sustainably.
Programme 3: **Land-use and aquatic ecosystem management**	**Scope:** This programme focuses on enhancing understanding of the effect of human interventions (land uses and decision making) on the environmental health of various water resources and/or ecosystems. As such the programme covers all water resource types, hence the inclusive name of National Aquatic Ecosystem Health Monitoring Programme is used, whereas the name River Health Programme focuses only on rivers.

Programme 4: **Integrated environmental and drinking water quality**	**Scope:** Within this programme research will be conducted to develop integrated methods and procedures which will be employed to protect people and the environment from the effects of poor water quality. The programme will develop methods and competence to support policies for the issuing of water or ecosystem use authorisations. This will promote the use of research knowledge in managing environmental water quality as required in the ecological Reserve, and thus reduce drinking water treatment costs.
Programme 5: **Ecosystem risks and disaster management**	**Scope:** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation. Existing tools and procedures will be assessed with the intention of refining/developing them. The success of the programme will be achieved by working closely with water resource managers and relevant government departments.
Programme 6: **Biodiversity and conservation**	**Scope:** The overall objective of this programme is to develop and integrate knowledge needed by the country in efforts aimed at protecting and preserving our unique biodiversity and natural landscapes. The projects will look at drivers (sociological, political and economic) that are critical in developing the understanding and competence necessary to sustainably manage the aquatic environment and its biodiversity. Collaboration and partnership with other institutions will be considered for this programme to achieve its aim.
Programme 7: **Ecosystem governance, legal framework and ethics**	**Scope:** Implementation of research outputs and regulations require appropriate governance systems and structures. The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this. The research under this programme should develop knowledge needed for good governance of water resources. The research will develop knowledge needed to support policy, planning and development that promote protection of ecosystems and water resources.
Programme 8: **Transboundary ecosystem management**	**Scope:** This programme will support projects that enhance ecosystem processes and functions, conservation and planning across regional and national borders. Transboundary research has gained some interest in recent years, and neighbouring countries or catchments will have to manage shared natural capital in an integrated manner. Collaborations with neighbouring countries and international funding agencies will be considered for research under this programme.

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Scope: This thrust addresses the rehabilitation, restoration and remediation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities, with the view to restoring, as far as possible, process, form and function in order to provide the stream of services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Support will be provided in building the capacity to implement the research findings. Remediation is the only addition to this portfolio. This is proposed to encourage innovative approaches that can be used in rehabilitation and restoration of water resources and their ecosystems. Research in this thrust will be carried out in collaboration with key stakeholders.

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

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

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

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

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

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

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

RESEARCH PORTFOLIO FOR 2017/18

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 3: Aquatic, riparian and land connectivity

Towards the development of a tool to quantify and monitor stream restoration success following removal of riparian alien invasive plants

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

2460

The main aim of this project was to measure stream faunal and floral recovery based on the biotic measures of aquatic flora (green algae, cyanobacteria), benthic invertebrate species diversity and abundance, and the abiotic indicators of nutrient dynamics, as a function of invasion (natural, cleared, or invaded sites). Three research objectives investigated were to:

- Quantify the effects of riparian restoration on stream species functional diversity and abundance of stream species
- Quantify the effect that riparian zone restoration has on nutrient cycling (nitrogen) on streams
- Assess sediment bedload as potential transporters of nutrients and for geomorphological modification
- Quantify the nature and significance of the relationship between functional diversity and abundance of stream organisms and nutrient cycling

Two perennial rivers located in the CFR, the Wit River (Bainskloof) and Du Toit's River (Franschhoek Pass) were chosen for this study. Each river had three experimental sites (reaches) named (A) near-pristine fynbos, (B) Acacia-invaded and (C) cleared. Mean sediment infiltration rates were significantly higher at the invaded sites than at the cleared and fynbos sites, increasing steadily downstream at the Wit River. TN and TP concentrations were significantly higher in the Wit River site infested with *A. mearnsii* compared to sections with native fynbos vegetation. This was expected because of the greater input of N-rich leaf litter, to the *A. mearnsii* invaded sites than to fynbos ones. However, no differences were noted between the invaded and fynbos site on the Du Toit's River. Functional feeding groups generally had no clear preference for either alien or native litter in any of the treatments across rivers. Invasive plant material transports nutrient-rich leaf litter and is therefore a key factor in changing trophic dynamics and energy chains, hence macroinvertebrate functional feeding group combinations. In complex and dynamic mountain stream systems such as the ones investigated in this study, local factors may play key roles, even masking effects on trophic food chains. Further research is recommended to cover the mountain to middle reaches of invaded rivers in order to inform better control of IAP by DEA.

R1 490 000
2015-2018

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

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

SAEON; Department of Water and Sanitation; University of KwaZulu-Natal (Pietermaritzburg); IWR Water Resource (Pty) Ltd; SANParks; Rhodes University; GCS Water and Environment (Pty) Ltd

2338

The Letaba River system in north-eastern South Africa is an example of a fully allocated catchment, with a semi-arid climate, which requires efficient management of all water resource demands. Most available water resources in this system have already been exploited, but progress is being made to implement the ecological Reserve or environmental water requirements (EWR) in the catchment, as required under the National Water Act (Act 36 of 1998). This has important bearing for the provision of ecosystem goods and services in the lower Groot Letaba River and the Kruger National Park (KNP). This progress stems from the implementation of an adaptive operational water resource management system, using a hydrological model to inform catchment managers how and when to make releases from upstream dams. However, one of the challenges with this system has been to account for suspected losses of water between upstream storage and downstream EWR target gauges. These losses may be described as transmission losses. The timing of the project also coincided with a severe, El Niño induced drought which allowed for novel insights into interactions between river flow and geohydrological and atmospheric drivers during periods of extremely low flow.

R882 000
2014-2017

Programme 3: Land-use and aquatic ecosystem management

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

North-West University (Potchefstroom); ARC Institute for Soil, Climate & Water; ARC Grain Crops

2347

The water resources in the North West Province (NWP) are exposed to various point and non-point pollution sources. Chemicals (antimicrobial substances, including metals, antibiotics pharmaceutical personal care products and biocides) are disposed of into the freshwater bodies. These come from various sources (agriculture, mining, poorly treated sewage effluent and sewage waste, etc.). The chemicals provide a selection pressure that allows for the survival of antimicrobial-resistant microorganisms. Various studies have, to a limited degree, demonstrated and supported this. However, the extent to which these water sources act as reservoirs for antimicrobial-resistant microorganisms (AMRMs) and antimicrobial-resistant genes (AMRGs) in the NWP is undetermined. Another aspect that is also undetermined is whether deteriorating water quality could be correlated to prevalence of ARMs and AMRGs. This project contributed to the understanding of the

point sources, patterns and impacts of the pollution, thereby allowing for identification of hotspots and formulation of effective management processes.

R1 470 000
2014-2017

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

North-West University (Potchefstroom); Jeffares & Green (Pty) Ltd; University of Johannesburg

2352

Out of 22 Ramsar wetlands, this project studied 8 sites based on the data availability and cost limitations. The results of the aquatic ecosystems indicated that many of the Ramsar sites are unique or have specific features that make the assessment of the sites difficult. For example, the diatom and macroinvertebrate communities within the Makuleke Wetlands indicate that each depression (pan) within the wetland is unique and contributes to the overall diversity of the system. There can be no doubt that some form of anthropogenic activity threatens each of the Ramsar wetlands that were included during this project. In general, these threats can be summarised as habitat loss, nutrient enrichment, numerous pollutants, urban and rural encroachment, alien invasive species, poor land use practices and organic enrichment. All of these could pose a significant threat to the Ramsar sites, presently as well as in the future. Management and proper monitoring will be the only effective tool to track and provide an early warning for the degradation of these Ramsar wetlands. The results gathered here provide a current baseline for monitoring. The data was used to update the Ramsar Information Sheets (RIS) that form part of the requirements of the Ramsar Convention. The study indicates that ecotourism at the Ramsar wetlands could be invaluable in generating income for the specific sites. However, it was obvious that the ecotourism potential for many of the Ramsar wetlands was still underutilised. Thus, there is significant potential to develop sustainable ecotourism and education initiatives at many of South Africa's Ramsar wetlands.

R1 774 700
2014-2017

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

Rhodes University; AWARD

2355

The main aim of this study was to develop and test a multi-sectoral integrative monitoring framework linked to a decision support system that will cater for bio-physical, economic and societal needs. The transdisciplinary work took the information from the disciplinary studies and integrated them throughout a three-year dialogue process with the Upper Komati Catchment Management Forum (UKCMF). Interactions were based on principles to encourage social learning. Perspectives from mine managers, regulators and members of local communities were researched following the Cultural Historical Analysis Theory (CHAT), then mirrored back to participants, and discussed. A ten-step multi-sectoral integrative monitoring framework was co-developed and linked to a decision support

system to be used by participants. These included officials from various departments, mining managers and consultants, regulators from DWS and the IUCMA and a wide range of community participants. Materials developed included the handbook 'How to engage with coal mines through a catchment management forum' and a set of maps and planning instruments that were developed collaboratively and tested with participants.

R2 000 000
2014-2017

Programme 4: Integrated environmental and drinking water quality

Development of an immobilized receptor-based EDC detection kit

Stellenbosch University; University of the Western Cape

2271

The increased pollution of the natural environment with endocrine active compounds necessitated the development of a rapid and cost-effective EDC-testing kit. Accordingly, this project contributed to the increase in human and environmental health by producing a novel EDC detection system. The system development was based on the principles of IMAC and consists of a PVP-PSMI nanofibrous membrane to which recombinant nuclear receptor ligand-binding domains are immobilised by metal chelation chemistry.

R1 070 000
2013-2016

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

CSIR; Nelson Mandela University; Department of Agriculture, Forestry & Fisheries

2464

The project successfully developed a multi-sectoral estuarine planning and management platform. This online tool (with all estuaries mapped) is now available for use in estuarine developments, such as coastal municipalities (especially wastewater management), DAFF (fisheries/mariculture), DWS (water allocation – Reserve), DEA (Marine and Coast Management) and any other practitioner who is involved in developments affecting the integrity of the estuaries. The Estuary Spatial Planning Platform weblink is available at: https://csir.maps.arcgis.com/apps/MapSeries/index.html?appid=a58ab2075a954549b9b1f8b5e063380e. The CSIR is at present one of the few state or parastatal organisations that have a Geoportal server and online ESRI licence that allows it to link and update datasets. In the short-term the CSIR will maintain and update the datasets. The information contained in the spatial planning platform can be used in various modes to inform strategic estuarine resource planning, including:

- Spatial visualisation (maps online) of the data and information
- Identifying potential conflicts and gleaning the potential sources of the conflict
- Rudimentary analysis of spatial information and data
- The overlay of different datasets in a sector and/or across sectors, provides the user with an oversight of important sector-relevant information and potential conflicts. More than 90% of the

information collated/generated as part of this project is associated with the NBA: Estuaries Component

R2 016 800
2015-2017

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

Fish invasions have been cited as a primary threat to imperilled South African fishes and other aquatic fauna. As a result, the management and control of alien invasive species is a legislated priority in South Africa (NEMBA: Act No.10 of 2004). From a river rehabilitation perspective, eradicating alien fish allows for the rehabilitation of several kilometres of river, with very significant benefits for the endangered fish species present and for the associated aquatic biota. In South Africa, the piscicide rotenone is one of the promising methods for achieving eradication. While alien fish removal by rotenone has been demonstrated to be an effective management tool, it has been surrounded by controversy in recent years due to its known and unknown collateral effects on non-target aquatic organisms. As a result, monitoring is an essential component of eradication projects. The primary objective of the research reported in this study was to use the Rondegat River as a case study to: (i) assess the efficacy of South Africa's first alien fish eradication project and (ii) provide information of how the ecosystem in a river recovers following treatment with rotenone. Treatment was conducted according to the guidelines in the AFS Rotenone SOP Manual. Rotenone was applied to the river using a series of drip cans sited at 7 locations spaced at approximately 1-hour water travel time intervals to maintain the recommended treatment concentration of 50 g/L rotenone during a 6-hour treatment. Six backpack sprayers were used to treat the backwater, seep, and spring areas with a 1% v/v CFT Legumine solution. To minimize off-target effects, deactivation of rotenone downstream of the water diversion weir was accomplished using a 2.5% w/v solution of potassium permanganate (KMnO4). Then monitoring was initiated for macroinvertebrates and fish for a period of 3 years, sufficiently covering all seasons. Data from a snapshot conducted in 2011 were also considered in analysis. Fish and macroinvertebrates fully recovered to close to the same density as before treatment, following eradication of small-mouth bass, *Micropterus dolomieu*.

R445 320
2013–2016

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

Stellenbosch University

2343

The study was conducted using in-situ and ex-situ (experimental) observations and measurements of the impact of herbicide treatments (glyphosate and others), fire and wood removal (resulting in nutrient dynamics – autochthonous or allochthonus) of *Acacia mearnsii* and *Eucalyptus camaldulensis*. Soil pH changed both with herbicide application and burning of slash piles, but in opposite directions, decreasing with herbicide and increasing with burning. Herbicides impacted soil through declines in pH, and can also add nutrients to the soil; however, it is unclear whether these impacts are long term or temporal. In the case of fire, soil pH changed with up to two units, and remained high even after a year of monitoring. Some alterations to soil microbial diversity and structure in response to fire were found; however, the impact of persistent high pH levels on soil microbial communities, soil plant interactions (nutrient uptake and symbiosis) remains to be determined. The role of floods that can 'reset' the template and mitigate the impacts of fire has been documented, but a more comprehensive study needs to be undertaken to determine the relationship between fire and floods in riparian ecosystems. The alternative to burning biomass is removal of biomass and, as was shown by this study, large amounts of nutrients can also be removed in biomass (especially wood in the form of wood chips or whole wood). Some of the negative consequences of the approaches to clearing may need to be traded off against the longer-term benefits of removal of woody invasive species from ecosystems.

Though the new knowledge generated is not conclusive (some uncertainties exist), the study provided an early warning on unintended consequences of alien plant control mechanisms that may arise. Further studies should be directed at influencing policy and operations.

R1 500 000
2014-2017

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

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

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

Prime Africa Consultants cc; North-West University (Potchefstroom); SANParks

2272

In the case of the Zaalklap system, a mining and industrial impact on a wetland-dominated system was analysed. Water quality results indicated that mines significantly impacted this wetland system negatively. Based on estimates done, the asset (or ecological infrastructure) value of the Zaalklap wetland ranges between R501–R763 million, of which the water purification and waste assimilation service contributes R130–R560 million. Thus, by rehabilitating the Zaalklap wetland at a cost of R1.7 million, we have been able to produce between R130–R560 million on the natural

asset balance sheet. This demonstrates that wetland rehabilitation forms a very important part of wetland impact mitigation strategies. This study indeed provided evidence that if ecological infrastructure is valued, proper decisions or mitigations can be made when there are new developments so that the future generation can still benefit from these natural resources. Finally, with the use of tools such as the bio-economic model, policy instruments should be developed and tested providing for additional regulatory, economic approaches toward ensuring economic development results in environmental preservation. However, standardization or acceptance of integrated bio-control models needs to be tested broadly in workshops and presented at dialogues, before finally being taken into policy as the approved method in evaluation of ecosystems and licensing.

R2 000 000
2013-2017

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

South Africa faces great challenges related to water scarcity and poor quality in most of its water supply systems. It is important to note that water carries a shared risk within these systems, with the growing demands in sectors such as agriculture and mining, as well as growing populations in municipalities contributing additional stressors to the already stretched resource. The resultant risks for business, broadly speaking, can be classified as reputational, physical, regulatory, financial and governance risks, should their water management strategies be found lacking. The experience of these risks, however, varies according to sector. There is increasing recognition by business to reduce their water risks through interventions that help to green their operations and value chains in order to respond to the challenges they face. A strategic approach to managing water risk exposure also helps businesses to identify new opportunities and build long-term competitiveness. Due to the fact that water poses a shared risk to business, and the general public, there is an opportunity to explore measures that promote action by business to create shared value. Green innovations provide an excellent opportunity to create shared value in the context of water management, through promoting interventions that result in improved business performance/society acceptance and the broader landscape and socio-economic betterment. The purpose of this study was therefore to begin to explore the opportunities through which companies could create shared value, by effectively understanding their relationship with water and in turn investing in interventions that add value both to the business and to their broader stakeholders. We envision the produced framework being used by corporate organizations as a guide in assessing the water risks in their value chains and to consider possible interventions as well as being used by government to understand the context of water management in business, which in turn can inform policy.

R1 333 000
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

Rhodes University; 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

The underlying research question guiding this project was 'how can village residents and the wider village community benefit from and bring benefit to the DEA-NRM's rehabilitation project?' The project team sought to engage with the community to explore ways in which landscape greening could enhance their livelihood and well-being. Four options were explored and achieved: rainwater harvesting for food gardens, vetiver nurseries, managed grazing and auctions for livestock production and a school environmental learning programme. The other fundamental product was the production of translated (isiXhosa) restoration drivers and rehabilitation guidelines for the community. The action research was the primary method of engagement, starting from traditional leaders, to ward councillors, to the broader community. More than 18 workshops were held during the lifespan of this project.

R2 000 000
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 Trust; University of Cape Town; NM Envirotech Solutions

2507

The research tools used were ethnographic in nature and included participant observation, one-on-one interviews with community members and representatives of the City of Cape Town (CCT) as well as focus group interviews. Ethnographic research is a particularly useful form of qualitative research which enables researchers to observe and/or interact with participants in their everyday lives. This allows for the researchers to gain a deeper understanding of the challenges and opportunities that the participants encounter within their environment and therefore the development of sustainable solutions becomes relevant and accepted within the communities. The outcome of these in-depth interactions was the development of a bankable business plan conceptualised by the Makhaza community who live along the Khayelitsha wetlands. The business plan (already accepted by City of Cape Town) not only included potential social and environmental enterprises, but also included the proposal for the development of a Green Hub that aims to create a platform for education, community building, conservation and empowerment for marginalised communities. This concept was developed in consultation with the African Centre for a Green Economy, Gender CC and the Environmental Monitoring Group (EMG), investigating the needs and

entrepreneurial opportunities that were available in relation to the protection of the Khayelitsha wetland. The objectives of the Green Hub include:

- Establishment of a platform for community-driven awareness raising on green economy
- Creating a local market place for green entrepreneurs to trade
- Incubate local green enterprises to explore the use of local resources and to upcycle waste materials

R600 000
2015-2017

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

The insurance sector has expressed an interest in co-producing products which reduce environmental systemic risk through better management of ecological infrastructure. This presents an exciting opportunity to move science into practice whilst simultaneously providing a space for collaboration and learning amongst researchers, actuarial scientists, landowners and government. One such new innovation discovered in this research is green bonds. They were suggested in one of the interviews as a potentially useful vehicle to raise capital to invest in ecological infrastructure.

Private and public organisations can raise finance through issuing bonds. A typical example is the municipalities and state-owned entities that entered into the bond market. The City of Johannesburg became the first municipality to list a green bond at the Johannesburg Securities Exchange (JSE) in 2014. The money raised from the R1.46 billion bond is being used to finance green initiatives such as the Bio Gas Energy Projects and the Solar Geyser Initiatives. Green bonds are attractive as the 'green' nature of the asset is often used to secure the bond with better terms than would otherwise have been. Municipalities are also able to ring-fence the money and only use it for investment in the green economy. The green bond concept can be expanded into conservation; however more research is required, such as exploring potential regulatory barriers and investigating how the policy and legislative framework could be altered to promote investment in ecological infrastructure. Investment in ecological infrastructure may require legislative, policy or operational changes, or a combination of these, within the financial sector. A clearer understanding of the existing financial policy and legislative framework in relation to investment in ecological infrastructure is needed and should be piloted in a co-funded study (insurers included) and tested/accepted guidelines produced.

R200 000
2016-2017

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 1: Ecosystems and population dynamics

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

Nxt2U (Pty) Ltd; CSIR; Department of Water and Sanitation; Hydrosoft Institute; Nemai Consulting cc; Hydrosol Consulting (Pty) Ltd; Cape Peninsula University of Technology; University of Pretoria; City of Cape Town Metropolitan Municipality; City of Tshwane Metropolitan Municipality

2339

All the waterways that were used in the case studies have been degraded beyond the ecological threshold. Without extensive rehabilitation, these water bodies no longer have the capacity to recover from degradation using natural processes, and they have also lost all their resilience and integrity. The investigations in the case studies showed that human settlements, whether formal or informal, tend to have adverse effects on river health, contributing to physical, chemical and biological degradation (e.g. *E. coli* count averages five million cfu/100 mL, phosphorus load in the Pienaars River is now approaching 100 t/yr going into Roodeplaat Dam). Of all forms of riparian land uses, informal settlements and wastewater treatment works were found to cause most of the pollution that has damaged the rivers and the associated riparian areas. In most instances, the river channels have already gone through many alterations over the years due to work associated with establishment of land uses, especially human settlements in urban and peri-urban areas. Increased localised flow volumes have resulted in increased incidences of flash floods as well as increased hydraulic energy in the water, which translate into higher erosive forces. Observations made during site visits showed increases in new settlements and other land uses in riparian areas. A rehabilitation framework that is founded on a political (constitutional and other social acts) drive is recommended by this study.

R1 500 000
2014-2017

Programme 2: Ecosystems and climate change

A climate change risk assessment of water hyacinth biological control

University of the Witwatersrand

2265

Water hyacinth is one of the world's most invasive aquatic plants. Originating from South America, it has invaded many ecosystems worldwide and numerous water bodies in South Africa since its introduction in 1908. With the cost of controlling invasive alien plants in South Africa exceeding R6.5 billion per annum and water hyacinth being considered as one of South Africa's worst weeds, control of water hyacinth in South African water systems is crucial. This study incorporates the effects of biological control by *Neochetina eichhorniae* weevils and temperature (on both weevils and plants) into a model of water hyacinth growth that will give site-specific predictions of population growth of both weevils and water hyacinth. Furthermore, as water hyacinth has more than one control agent released against it in South Africa, such as *Cornops aquaticum* and *Eccritotarsus catarinensis*, the success of this

research may provide proof of principle for modelling both potential and current biological control agents of water hyacinth.

R500 000
2013-2017

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

Freshwater Research Centre; SAIAB; Cape Nature; University of Cape Town

2337

Climate change predictions for the Cape Fold Ecoregion (CFE) include measurable increases in water temperature and decreased total runoff over the next 50 to 100 years. The predicted decrease in river flows and increase in water temperatures could potentially increase the risk of extinction for fragmented remnant populations of native biota. This situation presents a major challenge for conservation organisations mandated with devising strategies to prevent species extinctions. Designing effective conservation plans to safeguard these species and associated habitats into the future requires reliable information on species sensitivities to changes in temperature and flow; and on how climate change impacts will influence existing species population trends. This project represents the first attempt to examine the consequences of climate change for freshwater fishes in South Africa, if not in Africa. Despite being widely acknowledged as a top threat to biodiversity and ecosystem functioning, climate change impacts are notoriously difficult to quantify. This is partly because of the challenges associated with conducting studies at the timescales over which climate change processes operate, and partly because of the challenge of uncoupling climate change impacts from other threats and environmental pressures.

R1 860 100
2014-2017

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

Blackfly outbreaks along the middle and lower Orange River have the potential to cause losses to livestock production estimated conservatively at R300 million/annum. Such outbreaks occur periodically, with the most recent outbreak in 2011, and before that in 2000–2001. Economic losses occur along some 1 200 km along the middle and lower reaches of the Orange River between Hopetown and Sendelingsdrif. Typically, the blackfly species causing the problem is *Simulium chutteri*, although other species including *S. damnosum* and *S. adersi* cause outbreaks periodically. The outbreaks occur in spite of a scientific control programme, based on aerial (helicopter) applications of two different larvicides. The success of the control programme depends largely on correct timing of larvicide applications. There have been several attempts to reduce incidences of outbreaks including an integrated control programme and ongoing monitoring; probabilistic matrix-based model to predict annoyance periods of adult females; optimization of larvicide applications; and formation of an Advisory Committee,

but these have not had the desired outcomes. Part of the reason for this is that stakeholder interest tends to fade during periods when the problem has 'gone away', but resurfaces rapidly when there is an outbreak. This problem is typical of most pest control programmes, and highlights the need for long-term oversight and supervision of the control programme. This study therefore has developed a predictive management framework which incorporates a web-based platform and a mobile app. This will contribute to effectively managing the blackfly outbreaks and reduce the associated damage.

R1 200 000
2015-2017

CURRENT PROJECTS

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

R880 000
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

R1 000 000
2016–2019

Programme 3: Aquatic, riparian and land connectivity

Linkages between the hydrodynamic and biological drivers of the Mgobezeleni Catchment

Nelson Mandela 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

R2 700 000
2013–2015

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

R1 000 000
2015–2018

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

R760 000
2016–2019

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

R300 000
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

R1 700 000
2014–2018

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

R1 500 000
2016–2019

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

R1 578 947
2016–2018

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

R1 500 000
2016–2019

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

R1 000 000
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

R900 000
2016–2018

Programme 4: Integrated environmental and drinking water quality

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

Rhodes University

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

R2 000 000
2015–2018

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

R1 000 000
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

R1 500 000
2016–2019

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

R1 432 180
2014–2017

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

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

R2 500 000
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

R1 443 200
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

R500 000
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

R1 500 000
2015–2019

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1: Environmental economics (goods and 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

R2 907 000
2013–2018

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

R5 000 000
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

R2 000 000
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

R500 000
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

R1 000 000
2014–2017

Programme 4: Green economy and sustainable (green) innovations

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

R2 358 960
2016–2020

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

R2 000 000
2016–2020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 2: Ecosystems and climate change

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

R849 500
2014–2017

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

Nelson Mandela 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

R1 500 000
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 SO_2. Results from the model will be verified with actual data (dry and wet acid deposition) from other sources (e.g., Eskom and Josipovic data).

R700 000
2015–2016

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

R2 620 000
2016–2020

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: River, wetland, groundwater and dam processes

Revision of the Wet-EcoServices framework for assessing goods and services provided by wetland and riparian habitats

Eco-Pulse Environmental Consulting Services; FutureWorks; University of KwaZulu-Natal (Pietermaritzburg)

2737

Aims:

- Systematically review preliminary updates to WET-EcoServices tool and benchmark against international best-practice for ecosystem services assessment, including socio-economic considerations
- Expand WET-EcoServices to include non-wetland riparian areas
- Comprehensively refine the WET-EcoServices tool and associated guideline document based on the above review and systematic field testing
- Document a range of case studies in order to showcase the application of WET-EcoServices across a range of applications and contexts
- Provide recommendations for better integrating Wet-EcoServices outputs into the EIS tool

R1 292 000
2017-2020

Effect of water pollution on methane flux mechanisms within natural and constructed wetlands

University of the Witwatersrand

2770

Aims:

- To determine and compare methane emission rates of wetlands in pristine and urbanized environments were the influent water may have been subjected to pollution
- Analyse the microbial communities and biochemistry of natural and constructed wetlands with an emphasis on elucidating the mechanisms regulating methane flux and determining how this influences the value of the ecosystem services wetlands provide
- Train postgraduate student in aquatic ecology, microbiology and engineering

R800 000
2017-2020

Programme 4: Surface and groundwater interactions

Impacts of trace metals from geothermal springs to their surrounding soil and vegetation within Soutpansberg

University of Venda

2739

Aims:

- To determine the physicochemical parameters in geothermal springs, soil and vegetation
- To determine the trace metal concentrations and speciation (As, Cd, Cr, Co, Cu, Fe, Mn, Ni, Pb, Hg and Zn) in geothermal springs, soil and vegetation
- To show the correlation between the trace metal concentrations in the geothermal spring water, soil and vegetation
- To assess the potential health impacts of the trace metals on inhabitants
- To explore and measure the phytoremediative efficiency of the vegetation within the study area

R650 000
2017-2020

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

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

Water quality of the Sabie River and Inyaka Dam in relation to land-use practices

North-West University (Potchefstroom); Rand Water; SANParks; Inkomati-Usuthu Catchment Management Agency

2755

Aims:

- Investigate the current phytoplankton assemblages and water quality of the Sabie River catchment in terms of physical, chemical and biological factors
- Assess the land cover and land-use practices of the Sabie River catchment
- Relate the present phytoplankton assemblages and water quality of the Sabie River catchment to land cover land use practices

R200 000
2017-2019

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 3: Environmental risk management

A holistic integrated approach to assessing and implementing ecological water requirements

North-West University (Potchefstroom)

2738

Aims:

- To strengthen research and training in environmental water requirements (EWRs)
- To advance the technical integration of EWRs using science-based methodology
- To demonstrate the implementation of the integration of EWRs by means of a case study
- To further develop and strengthen water-related skills
- To present a workshop to highlight the results of this research

R1 000 000
2017-2020

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 4: Green economy and sustainable (green) innovations

The blue economy from an ecosystem integrity perspective with particular focus on coastal resources and communities

Greenhouse Systems Development; Nelson Mandela University; University of Pretoria; AFRICEGE; FutureWorks; Informal South (Pty) Ltd

2736

Aims:

- To develop sustainable economic models necessary to support the blue economy
- Pilot test the business model using selected case studies in both warm and cold temperate coastal zones
- Integrate the best practise into draft SA blue economy strategy and related legislation
- To develop a model and guiding framework on how coastal ecosystems can support the blue economy that benefits local and broader communities
- Share knowledge generated with local and global networks and stakeholders

R1 600 000
2017-2020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 2: Ecosystems and climate change

Kukimbia: the impact of environmental refugees in Southern Africa

CSIR; United Nations High Commissioner for Refugees; Rhodes University

2768

Aims:

- To develop the southern African policy position on environmental refugees affected by floods and droughts and provide policy guidelines to strengthen this in regional law
- To develop national policy guidelines on environmental refugees to strengthen national disaster response plans for floods and droughts in the case study areas identified
- To develop local adaptive management strategies for environmental refugees in the case study areas identified

R1 900 000
2017-2020

Climate change and South Africa's blue carbon ecosystems

Nelson Mandela University; University of the Western Cape; SAEON; CSIR

2769

Aims:

- To determine the extent of blue carbon ecosystems in South Africa and estimate blue carbon storage using the IPCC assessment methods
- To quantify the loss of blue carbon habitats and associated ecosystem services
- To predict the response of blue carbon ecosystems to climate change in the form of sea-level rise and increased global temperatures

R1 250 000
2017-2020

Programme 3: Ecological thresholds

Vulnerability assessment and adaptive response for smallholder/small-scale livestock sector to the changing climate

Khanimambo Innovative Solutions; Ramies Field Researchers

2766

Aims:

- Conduct vulnerability assessment of smallholder/small-scale livestock farmers to the impacts of climate change
- Determine future climate change impacts on livestock in the smallholder/small-scale sector
- Characterize the impacts of climate extremes on livestock production (drought, heat, waves, floods, etc.)
- Determine the livestock water use efficiency (current and in the projected climate change)
- Identify priority areas in the country where this small-scale farming sector will be affected and determine the necessary adaptive responses
- Cost the relevant adaptation options identified (environmental and economics)
- Recommend adaptation strategies that will increase the farmers' resilience and adaptive capacity

R1 000 000
2017-2020

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KSA 3: WATER USE AND WASTE MANAGEMENT

SCOPE

The Water Use and Waste Management KSA focuses mainly on the domestic, industrial and mining water sectors. It aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. This KSA also supports studies on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability.

Research on infrastructure for both water supply and sanitation is included. A further focus is on water supply and treatment technology serving the domestic (urban, rural, large and small systems) as well as the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors with the aim of improving productivity and supporting economic growth while minimising the negative effect on human and environmental health.

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

our country, especially in the light of problems related to the deteriorating quality of our water resources and the rising costs and reliability of energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond to the issues of poor O&M, competency and capacity constraints, reuse, energy efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

OBJECTIVES

The strategic objectives of KSA 3 are as follows:

- To support the efficient functioning of water service institutions and their viability in order to sustain water services in rural and urban areas
- To develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality
- To develop technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector
- To quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycle, recovery and beneficiation with the aim to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries
- To provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector

THRUSTS AND PROGRAMMES

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

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

Programme 1: **Cost-recovery in water services**	**Scope:** The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this programme intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.
Programme 2: **Institutional and management issues – Water services**	**Scope:** Relationships and partnerships between service providers, both external and internal, are important prerequisites to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.
Programme 3: **Innovative management arrangements – Rural water supply**	**Scope:** The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development.
Programme 4: **Regulation of water services**	**Scope:** Regulation of water services is important for the sector to achieve improved functioning and performance in the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.
Programme 5: **Water services education and awareness**	**Scope:** A fully-informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

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

Programme 1: **Drinking water treatment technology**	**Scope:** The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.
Programme 2: **Water treatment for rural communities**	**Scope:** This programme aims to produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.
Programme 3: **Drinking water quality**	**Scope:** The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.
Programme 4: **Water distribution and distribution systems**	**Scope:** The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to end-users. The programme has the following expected outcomes: to develop reliable processes in predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs; to ensure that the quality and quantity of water is maintained in the distribution system – from the water treatment plant to the furthest end-user; and to develop innovative methods, tools and processes that will improve system integrity and reliability.

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

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

Programme 1: **Emerging treatment technologies – Preparing for the future**	**Scope:** It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as to support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment, etc. It also supports research aimed at informing future policy through data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.
Programme 2: **Application of appropriate technologies and tools**	**Scope:** This programme addresses the improvement and innovative application of existing 'fit for purpose' technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate application to consistently achieve strict standards, with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.
Programme 3: **Stormwater and sewerage systems**	**Scope:** The programme supports the strategic and technical aspects of managing stormwater and sewerage and their impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology including water-sensitive urban design (WSUD) and stormwater reuse. It will cover technical design, operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.

Programme 4: **Wastewater sludge and faecal sludge management**	**Scope:** All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, de-watering, disinfection and beneficiation is encouraged.
Programme 5: **Sanitation technology and innovations**	**Scope:** To develop innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

Programme 1: **Emerging challenges and solutions for the 21st century**	**Scope:** This programme seeks to look at major challenges that may face South Africa in future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable future industrial complexes and their water management will allow for better planning and regulation of new industries, enabling improved adoption of integrated resource management systems, processes and tools.
Programme 2: **Integrated management**	**Scope:** This programme focuses on integrated and innovative management arrangements, e.g., public-private partnerships (PPP), to support industry and government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.

Programme 3: **Quantification, prediction and minimisation of water use and waste production**	**Scope:** In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.
Programme 4: **Governance, policy, regulatory, and economical instruments to improve industrial water management**	**Scope:** The regulatory authorities are responsible for authorising and regulating the impact of industrial waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used almost exclusively to manage water quality. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new approaches are believed to be more cost-effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective in order to improve, review and enable implementation.
Programme 5: **Water efficiency, cleaner production, beneficiation and treatment of industrial effluents**	**Scope:** This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial activities, and thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycle, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse, and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary economy opportunities within South Africa.

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

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

Programme 1: **Water use and waste production**	**Scope:** This programme focuses on investigations into quantification of water used and waste produced by the sector, currently, and predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.
Programme 2: **Regulatory, management and institutional arrangements**	**Scope:** The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point-source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: Policy development falls under KSA1).
Programme 3: **Minimising waste production**	**Scope:** This programme focuses on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.

Programme 4: **Mining in the 21st century**	**Scope:** The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, etc. (especially innovative ideas and piloting/scale-up).
Programme 5: **Low-volume mined products**	**Scope:** Much research attention has been paid to coal and gold mining; however, other quarried or mined products such as radio-nuclides and platinum group metals also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.

THRUST 6: WATERSMART FUND

Scope: Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments.

Thus, this fund will support research, demonstration and development of any innovative idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PORTFOLIO FOR 2017/18

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – 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

The objectives of this study were to provide a 'proof of concept' or evidence that demonstrates that Strategic Adaptive Management (SAM), or an adaptation thereof, can be applied to water services in South Africa and to examine whether SAM could be practically applied to water services. It was evident from the literature that SAM has significantly addressed the barriers to adaptive management through the adoption of theories, concepts, principles, processes, and practices that are being utilized in effective organisations, including in business. In addition, it provides solutions to overcome 'silos' and fragmentation by building integration and collaboration into its process. Key to the effectiveness of SAM is the emphasis on developing generative leadership, the building of trust between all stakeholders, the importance of the vision (desired future) and strategy being developed and owned by stakeholders, the central role that values play in driving the behaviour of stakeholders and 'structures' that guide decision making and finally the institutionalisation of the management process, in this case, SAM. Based on these conclusions from the literature review, SAM could be useful in municipalities and has a significant probability of succeeding, especially in contexts that are relatively stable and functional. However, SAM is not a 'silver bullet' – a direct or effortless solution to the problems being faced in water services. Rather, it is argued that an adapted and improved version of SAM has the potential to act as a process for overcoming the challenges of traditional management and operationalising a paradigm shift to improve the delivery of water services.

R300 000
2016-2017

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

Cape Peninsula University of Technology; City of Cape Town; eThekwini Municipality; Department of Water and Sanitation; University of the Western Cape

2208

As water resources become limited, reclaimed water has been identified as an alternative resource for augmenting water supply. However, its implementation is contentious due to public perceptions, as well as institutional weaknesses, thereby influencing ways in which both institutions and the public respond to issues of water scarcity and choices, and engage in order to facilitate user acceptance of reclaimed water. The overall aim of this study was to investigate and test the major factors that govern people's decisions towards the acceptance or rejection of reclaimed water for drinking purposes. Findings from this study showed that public perceptions of risks associated with using reclaimed water are initially dominated by the 'yuck' factor because the idea is at first repugnant. Deterioration of the quality of water, fear of drinking water of sub-standard quality, restrictions, tariffs and willingness to pay, and reduced water use were also identified as additional factors that govern the public's decision to accept or reject water reclamation. Emotions underlying public perceptions that prevail at different institutional stages of implementing water reclamation include doubt and denial, mistrust, fear and safety concerns. Although rooted in knowledge deficits, emotive issues were often associated with mistrust in municipal capacity to implement safe water reclamation and a lack of choice. One of the case studies investigated demonstrated how public perceptions, if not addressed, can cumulatively contribute to public resistance. In all cases, it was evident that public trust in institutional processes for water reclamation needed to be strengthened. Based on these factors, a framework guideline for assisting municipalities with addressing public knowledge deficits and public engagement challenges within the institutional decision-making process for introducing reclaimed water was developed. Appropriate interventions can be implemented throughout the project lifecycle stages, namely, planning, decision making, implementation and post-implementation.

R1 180 000
2013-2017

Programme 4: Regulation of water services

Extending performance monitoring and analysis in South Africa

Nelson Mandela University; Extra Dimensions 47 cc

2359

One of the most important ways we can advance the scientific understanding of municipalities' (i.e. Water Services Authorities) performance is to continually revisit previous research with new data and new approaches. Here the goal was to understand how to better measure the performance of the Water Services

Authorities (WSAs). This study assessed the suitability of new approaches, namely, the stochastic frontier analysis (SFA) and data envelopment analysis (DEA) as tools to help evaluate the efficiency of WSAs. Although the efficiency of the water sector has been studied utilising either DEA or SFA in other parts of the world, this was the first such attempt in South Africa. Most importantly, little is known about DEA and SFA's comparative performance. This study applied the two leading and sophisticated techniques to efficiency measurement, to the new dataset for the South African water sector and compares the efficiency from the two new techniques. DEA yields lower efficiency scores than its SFA counterpart. The study thus found that SFA scores generated correlate with those obtained using DEA, which increases our confidence in the estimates we made in the efficiency analysis of WSAs. The efficiency scores should not be interpreted as the absolute efficiency of the WSAs, but rather as a relative efficiency. Although the two methods are complementary in nature, SFA is deemed to be the best methodology. It is preferred over DEA for its ability to account for data noise, such as data errors and omitted variables. Moreover, this approach allows for standard statistical tests to be used to test hypotheses on model specification, and on the significance of the variables included in the model. Furthermore, SFA is more amenable to modelling the effects of other variables (e.g., differences in population size, environment, quality, and the type of WSA – whether it is a metro or district or local municipality).

R840 000
2014-2017

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Modelling advanced oxidation of persistent chlorohalogenated pollutants in aqueous systems

University of Pretoria (Chemical Engineering); Sedibeng Water

1125

One of the most promising technologies for dealing with emerging pollutants of concern, such as, chlorohalogenated compounds, has been the implementation of advanced oxidative processes (AOPs), as they are generally non-selective and have the potential to completely mineralise most organic chemical species. Although photocatalysis has been demonstrated to completely remove a range of chemical pollutants in mixed reactor aqueous systems, the exact photocatalytic mechanisms for functional group transformations are not adequately understood as the reactions associated with heterogeneous photocatalysis are diverse and may include oxidation, cleavage, reduction, geometric and valence isomerisation, substitutions and more. Without knowledge of the intricate behaviour and chemical interactions of many pollutant classes that constitute the typical wastewater and water discharges, efficiency in treatment and performance will not be realised. This study aimed at determining the kinetic trail and reaction routes undertaken in the oxidation process

towards mineralisation, especially important when dealing with a wide range of organic pollutants that are simultaneously being treated. Chlorophenols were used as model compounds for this study as they have simple configurations, are stable, and depict strong reactivity upon initiation under aqueous conditions. The study found that single compound oxidation efficiencies of the different chloride substituted phenols showed that higher level substituted compounds were progressively less efficiently removed. The degradation of simultaneously oxidised chlorophenols and phenol recorded a reverse sequence to that of single compound determinations, with the exception of phenol, which remained the least efficient in oxidation. The chemical transformations of simultaneously photocatalysed polychlorinated substituted phenols are fractionally accumulative at the expense of others, which means that the consumption of higher level substituted chlorophenols led to an increase in the concentrations of lower level substituted chlorophenols. The findings in this study provided insight on the complicated nature of heterogeneous photocatalytic reactions. Thus, each class or group of compounds may not necessarily follow the same reaction scheme due to many factors that influence the photocatalytic mechanism. It would therefore be recommended that many determinations be performed on diverse groups of chemical compounds.

R200 000
2016-2017

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

University of Venda; University of Johannesburg

2363

Groundwater is a source of drinking water for most rural communities in many developing countries due to lack of municipal water supply. However, the groundwater may contain chemical species above recommended limits for drinking water and could be detrimental to human health. Such a chemical species of concern is fluoride which is often present in high concentrations. A number of techniques have been developed for defluoridation of groundwater, such as adsorption, ion exchange and precipitation processes, membrane processes such as reverse osmosis, Donnan dialysis, electro dialysis and nanofiltration. Of the methods developed so far, adsorption using locally available natural adsorbents has been identified as the only technology that is most suited for rural defluoridation devices. This project was designed to develop and evaluate novel metal-modified natural clay adsorbents for groundwater defluoridation. Novel adsorbents tested included locally available smectite-rich clay soils and diatomaceous earth, either in their raw form or modified with high charge density cations Al^{3+}, Fe^{3+}, Ce^{3+}, Mg^{2++} and Mn^{2+}, their oxides or mixed oxides/hydroxides for defluoridation of groundwater from the Limpopo Province. The developed adsorbents had varying adsorption capacity, from moderate to high, as compared to adsorbents reported in literature.

The raw clays and diatomaceous earth had adsorption capacity ranging from 0.08–0.34 mg/g. Modification of the clays with various metal cations and their oxides increased their adsorption capacity (0.65–1.59 mg/g). The modified DE had adsorption capacities ranging from 0.6–1.73 mg/g. These adsorbents exhibited potential for application in household defluoridation devices based on their chemical stability and high adsorption capacity. Moreover, the Al/Fe-modified DE showed capability for removing common pathogens of faecal origin found in surface water, further enhancing the quality and safety of drinking water. Further evaluation and optimization of the Al/Fe, Mg/Ce/Mn-oxide modified DE/clay soil composites/mixtures is recommended for fabrication of ceramic candles and discs for application in household water treatment devices.

R690 000
2014-2017

Functionalized electrospun fibres containing immobilized nanoparticles in nanocomposite sorbents for the removal of metals, organic pollutants and bacteria from surface water

University of Johannesburg

2365

The study set out to fabricate filters capable of removing organics, metals and micro-organisms. The study focused on fabricating electrospun nanofilters or nanosorbents with different functionalities capable of removing trace metals as well as multilayer membranes impregnated with nanoparticle catalysts for degradation of organics and microbes. Owing to their small diameters, high surface area to volume ratio, and low porosity, these electrospun nanocomposite filters are expected to be efficient in removing most water contaminants. Synthesis of the different filters was achieved. Using simultaneous dechlorination and catalytic photodegradation, a 99% degradation for pesticides (diuron, fipronil dieldrin and chlorpyrifos) was observed. Furthermore, this study has shown a reaction pathway that is equally supported by literature which explains why reductive dechlorination may take place at ambient temperature while hydrodechlorination would require a temperature of about 400°C. The novelty and new knowledge in this study is in the simultaneous one-step process of dechlorination and catalytic photodegradation which was non-selective to the compounds in the sample. The biosorbents used (polysaccharide extracts) were applied in water treatment in powdered form, as well as in nanofibres, for the removal of Pb^{2+} and Cd^{2+} from water. The maximum adsorption capacities of polysaccharides for removal of Pb^{2+} and Cd^{2+} as 256 and 151 mg/L, respectively, were obtained. These values are relatively high compared to that reported in literature for natural biosorbents. The capability of the hemicellulose/pectin nanofibres to remove natural organic matter (NOM) fractions from wastewater was investigated. Using relatively novel technologies, namely, LC-OCD and FEEM together with modelling, the distributions of NOM in the raw water and after filtration were assessed. Silver nanoparticles immobilized on nanofibres were applied to remove bacteria from raw wastewater. The AgNCs polymer composites obtained in this study showed antibacterial properties, towards Gram-positive and Gram-negative bacteria.

R650 000
2014-2017

Natural organic matter (NOM) in South African waters: treatability, removal and development of techniques for removal of disinfection byproducts in water

Unisa; Magalies Water; Eskom; Rand Water

2468

Natural organic matter (NOM) is an intricate and diverse mix of humic acids (HA) and non-humic substances (NHS) widely found in aquatic systems like rivers and lakes, and its removal is challenging because of both variation in character and resistance to biodegradation. Thus, to completely remove NOM, its character must be determined. Results from this study have shown that conventional removal approaches, including coagulation, adsorption, ion exchange, and oxidation, that are currently used to remove NOM from raw water used for drinking water production, vary in NOM removal efficiency depending on its character. Amongst these, oxidation using chlorine dioxide has shown great potential. Photodegradation of various raw water samples obtained from the various water treatment plants located in South Africa using N, Pd co-doped TiO_2 (NPT) revealed that the treatability of NOM was not uniform across various water sources. It was also evident from the results obtained that the raw water samples with the highest content of the hydrophobic fraction of NOM had the highest removal efficiency. Overall, this study has revealed that NOM is not monitored in raw water (TOC is used as an overall indicator), and that the potential for formation of disinfection by-products is still manageable as the final water from most of the plants surveyed was within SANS 241 standards.

R500 000
2015-2017

Guidance on drinking water treatment system performance assessment and optimisation

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

2578

The main aim of the Blue Drop certification programme is to incentivise regulatory compliance to drinking water quality standards and also proactively measure all the aspects contributing to a sustainable water services business. Since inception, regulatory performance has always been a priority; however, it is important that drinking water supply and treatment remains sustainable in an environment where more has to be done with less on a day-to-day basis. To ensure compliance, Water Services Authorities are required to conduct and submit a process audit report to the Department of Water and Sanitation on an annual basis. The content and format of the process audit report however remains problematic as this varies broadly in the sector. With regards to promoting efficiencies during water production, little has been done. Thus, in this study, a guideline has been developed to provide guidance on the requirements of process audits and also plant optimisation studies. A survey of various water services institutions showed that some require that a process auditor be an engineer while others are satisfied if the inspector is a scientist or a professional process controller. Recommendations from this study stipulate that an inspector will have: (i) an advanced tertiary qualification in a water treatment related field; (ii) will have at least 10 years' experience in the field of water treatment and (iii) a professional registration with an appropriate regulatory body.

R1 000 000
2016-2018

Programme 2: Water treatment for rural communities

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 was then recommended as a possible treatment method, as 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. The 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. Results of the social perception study indicated that 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.

R900 000
2014-2017

Development of resource guidelines on greywater use and management

University of Cape Town; Stellenbosch University

2592

The management and use of greywater can pose significant risks, specifically in terms of the potential health and environmental hazards from chemical and microbiological contaminants and disease vectors, depending on the source of the greywater (e.g. serviced or unserviced settlements), the treatment process adopted, and the use for which it is intended. Greywater quality is highly variable, and there is a need to develop guidelines to not only ensure the safe management and use of greywater as an alternate water resource, but also to limit and manage inappropriate disposal in areas where it has the potential to result in major health hazards; specifically in low-income housing and informal settlements. Through the development of a set of guidelines, this project aimed to address (and mitigate) the risks associated with the management and use of domestic greywater, and support the wider uptake of this practice in South Africa – such that the diverse benefits that greywater use may offer can be realised. These include building resilience into the water supply system; managing water demand, reducing volumes of greywater to wastewater systems; and reducing diffuse pollution loads from unserviced settlements. The guidelines were compiled using updated information from various WRC projects that considered different aspects of greywater management, as well as the outputs from other affiliated research projects. These guidelines are based on existing knowledge and expert opinion, and are simply meant to provide background information to national and local government policy makers so that appropriate legislation can be drafted – with the oversight and duty of care thus remaining with these policy-makers. It is likely that this document will form the foundation for future research and policy development regarding the use of greywater as an alternative water resource; it should be emphasised that not enough is known currently about the long-term effects of greywater use on human health and the environment in order to make definite decisions about this practice. It should also be noted that guidelines are aimed towards household-level, onsite greywater use within serviced settlements; and for managed facilities in government buildings, office blocks, schools, hostels, etc. Institutionalised greywater use is not advised in the informal, densely-settled areas of South Africa where conditions are such that the management of the risks involved with this practice becomes too difficult. In these areas, the main focus needs to be on sanitation provision to address issues of untreated sewage being disposed into the environment, as well as dealing with leakage and/or wastage of water. The report and the guidelines are not meant to be a prescriptive 'manual' or set of rules regarding the use of greywater as a resource in South Africa, but are rather aimed at providing a South African context for the inclusion of greywater as an alternative, non-potable resource, particularly during times of water scarcity.

R263 000
2016-2017

Development of resource guidelines for rainwater harvesting

CSIR

2593

Rainwater harvesting (RWH) is an age-old proven practice; however, an enabling environment and government support are necessary in order to promote the implementation of RWH systems on a larger scale in South Africa. There are no regulations that specifically govern RWH in South Africa. However, the National Building Regulations (SANS 10400) which governs all building and construction work in South Africa, and other consumer installation standards (SANS1200, SANS 10106, SANS 10106, SANS 10252 and SANS 10254) do affect aspects of RWH systems such as tank installations, internal plumbing, etc. While relevant Acts make provision for the enforcement of such regulations, there is still a need to put in place the necessary resources for enabling implementation and regulation. Regulations should not be stringent to the extent of making it difficult for the average homeowner to set up a basic RWH system. Nor should they be too lax to fail to prevent the backflow of rainwater into the main water supply system. Accordingly, existing regulations should apply for dual water supply systems but should be waived for stand-alone systems. The South African rainwater harvesting guidelines are the primary source of information and decision-support to all stakeholders. The guidelines contain similar information to what is available in the international literature and a number of guidelines; however, the information here is tailor-made to South African conditions. The ultimate purpose of the guidelines is to enhance water security by mainstreaming domestic rainwater harvesting into the development and management of water resources in South Africa.

R344 000
2016-2017

Programme 3: Drinking water quality

Extending EDC Toolbox I to include thyroid and androgenic bioassays

University of Pretoria; Griffith University

2303

Endocrine disrupting compounds (EDCs) are ubiquitous in our daily lives, eventually ending up in the aquatic environment, either as the parent compound or breakdown products. Present as mixtures in the aquatic ecosystem they can have effects on the endocrine system, such as testicular, breast and prostate cancers, declining sperm counts, pregnancy loss, pubertal abnormalities, reproductive organ deformities, neurological problems, diabetes and obesity. Exposures early in life can trigger onset of diseases in childhood and later in life and subsequent generations. Currently available EDCs testing strategies are limited to a known spectrum of ED effects, and are inadequate to detect

endocrine disrupting effects that are linked to human disease. This project was aimed at expanding the suite of assays for testing EDCs developed in the initial Global Water Research Coalition Toolbox I by assessing additional endpoints other than just oestrogenic activity. Thus this study was part of the GWRC Toolbox II project aimed at developing and validating methods that will test a range of other endocrine endpoints such as androgenic, thyroid, progestagen, glucocorticoid, retinoid (RXR) and peroxisome proliferator (PPAR) activity for a variety of water samples. The GH3.TRE. Luc thyroid and the MDA-kb2 androgen assays were successfully established and optimised in the laboratory and were used to test EDC effects on surface, tap and treated wastewater from six different countries including South Africa.

R430 000
2014-2017

Programme 4: Water distribution and distribution systems

State-of-the-art in advanced metering technology and application
University of Cape Town
2370

Advanced water metering is part of a much larger movement towards smart networks and intelligent infrastructure. In high-income countries, advanced metering technology is generally focused on the need to obtain meter readings without human intervention. However, in South Africa and other developing countries, advanced water metering (specifically in the form of prepaid meters or water management devices) has developed along a parallel path, driven by the need to provide services to previously unserved communities and deal with the problems caused by rapid urbanisation. Advanced metering has the potential to provide substantial benefits if appropriately applied. However, compared with conventional metering, these systems are expensive and complicated and often rely on technology that is still being developed. Advanced metering systems therefore carry a higher risk of failure, poor service delivery and financial losses unless implemented with careful design and thorough planning. The entire project lifecycle should be considered when determining the feasibility of advanced metering, including product selection, project implementation and operation & maintenance. This will enable utilities to make more realistic projections of economic, environmental, social and technical benefits, if any, before the scheme is put into place. Taking into consideration the overall benefits gained compared to the challenges faced in most of the case studies above, it is critical that utilities approach advanced metering as part of many alternative solutions to a particular problem, not as a goal in itself.

R1 280 000
2014-2017

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

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

University of Cape Town; City of Cape Town Metropolitan Municipality; University of the Western Cape

2412

This study has explored the challenges to and opportunities for the implementation of WSD in South Africa, mainly from a technical perspective – as highlighted through detailed catchment studies. The future development of policy on WSD in South Africa will likely be informed by the various different components of the project aimed at identifying opportunities for implementing the various WSD tools and techniques in selected urban catchments – including rainwater harvesting (RWH) and stormwater harvesting (SWH); sustainable (urban) drainage systems (SuDS); water conservation and water demand management (WCWDM); water-efficient devices, greywater harvesting, and groundwater use linked to managed aquifer recharge (MAR). WSD elements have been assessed in the design/redesign of precincts of the selected catchments to demonstrate how WSD could potentially improve water quality, water quantity, biodiversity and amenity value – thus creating liveable, sustainable and resilient outcomes for urban areas. A key finding of WSD-related research in South Africa is that while much can be gained from international experience, there is a need to test technologies within the local context. Much of the focus to date on WSD technology options has, however, been on alternative water sources, with limited research on issues such as: stormwater, treated effluent and groundwater/MAR management activities associated with WSD; and the development of appropriate systems that promote amenity and biodiversity as part of WSD implementation projects in South Africa. Conceptualising the implementation of WSD requires an interdisciplinary perspective of a range of factors (technical; environmental/climatic; social; economic), many of which will be site specific. The research also indicated that while different WSD technologies may provide certain benefits in isolation, these benefits can either be substantially increased (e.g. where a treatment train is used for stormwater quality management), or decreased (e.g. where multiple alternative water sources are being used to supply water for only one end use).

R2 000 000
2014-2017

Energy and resource recovery from wastewater sludge – a review of appropriate emerging and established technologies for the South African Industry

TruSense Consulting Services

2475

This project evaluated one innovative/emerging and two established sludge-to-energy technologies that have not yet been implemented in South Africa, so as

to understand their potential implementation within the South African water sector. The selected technologies were: (i) emerging enhanced hydrothermal carbonization polymeric carbon solid (PCS) technology; (ii) established advanced anaerobic digestion using thermal hydrolysis (TH) as the sludge disintegration technology followed by mesophilic anaerobic digestion (MAD); (iii) gasification technology which is established for coal and woody biomass conversion. The scope of the project included technical and economic evaluation of the implementation of each technology at a typical South African WWTP utilising conventional MAD for sludge stabilisation of capacity 155 ML/d producing about 50 tDS/d combined primary and waste activated sludge. The key findings from the project were:

- Both the PCS technology and advanced TH-MAD are more economically attractive than conventional MAD
- The PCS technology is the most economically attractive technology with the highest positive NPV
- Apart from being the most economically attractive, the PCS technology offers other unique advantages over established technologies to the South African water sector such as:
  - Ability to process a wide range of biomass thus combining sludge and screenings management
  - Ability to couple with existing technologies such as conventional MAD, advanced TH-MAD or gasification; a positive NPV was obtained for the 35 tDS/d retrofit to conventional MAD
  - Potential to destroy contaminants of concern such as endocrine disrupting compounds
  - Beneficial use of residual sludge or ash is more economically attractive than disposal to landfill

R950 000
2015-2017

Biomimicry wastewater treatment technology – monitoring and evaluation

Isidima Design and Development (Pty) Ltd

2479

This study developed a monitoring and evaluation framework for the application of innovative biomimicry wastewater treatment technology to treat greywater (and manage stormwater) in informal settlements as part of the required careful monitoring of the different components of the systems, how they evolve over time, as well as the water quality. The developed monitoring framework process, enables the efficiency and efficacy of these treatment systems to be evaluated to determine the suitability of this technology in this and similar contexts. The developed monitoring programme included five key categories, namely; operational, physical, chemical, microbiological, and ecological. An initial trial of this methodology confirmed the suitability of this approach as a useful tool for monitoring the performance of the biomimicry-based treatment systems. Since the monitoring and maintenance of the systems in the Langrug informal settlement is done by community members, simple checklists and systems for monitoring by the community were developed aligned to local community skills to enable effective monitoring of the maintenance requirement. In this regard, initial observations and water quality analysis have confirmed that the greywater prototypes installed in Blocks S and T of the Langrug community effectively separated the highly polluted greywater from stormwater flows, directed greywater flows using a network of pipes to tree gardens and micro-wetlands, thereby enabling the productive use of this water to contribute to the creation of green space within the informal settlement. The tree gardens significantly reduced the greywater

flows discharging from the prototype into the sewer. As expected, the prototype only achieved minimal treatment performance, but does prevent the migration of solids which could lead to pipe blockages, while the planned Eco-machine at the bottom of the settlement would provide effective treatment of this wastewater based on studies at Plankenbrug. In this regard, the water quality samples taken during stable operation periods of the Plankenbrug Green Filter have confirmed a 99% reduction in the *E. coli* through the system from greater than 10 million *E. coli* per 100 mL to 4 700, with effluent concentrations reaching as low as 16 *E. coli* per 100 mL for lower flow rates. A significant reduction in ammonia (73%), phosphate (84%) and chemical oxygen demand (65%) was also observed as part of monitoring. These findings suggest that the biomimicry wastewater treatment systems have the potential to treat polluted effluents to a suitable quality that complies with the general authorisation limits for the discharge of treated effluent.

R500 000
2015-2017

Programme 2: Application of appropriate technologies and tools

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

Durban University of Technology; eThekwini Municipality; Umgeni Water; Columbia University

2376

The aim of this study was to develop an online database for South African wastewater treatment works, and to use this online platform to establish a strong network between wastewater engineers, microbiologists, works operators and the wastewater research community at large to holistically solve the broader challenges facing the South African water treatment sector. Based on the major functional microbial populations assessments for six WWTWs, and historical and literature-based data, an online database, 'WastewaterConnect.co.za' was developed to act as an online resource for holistic skills development for the wastewater research sector, and to provide access to information that supports the larger South African water community. 'WastewaterConnect' consists of the following 5 pages:

- Map/wastewater treatment plant locator
- Wastewater information hub, containing an accumulated repository of wastewater-related information
- Techniques, outlining the most common, useful and most effective methods and techniques already optimised for wastewater
- Equipment hire – information regarding equipment support
- Blog – that fosters a culture of open discussion, and promote collaboration

It is anticipated that the online resource will develop into a practical guidebook on applied wastewater treatment, specifically catering to the local wastewater sector. Furthermore, the site is envisioned to also become a comprehensive troubleshooting guide aiming to solve practical problems by holistically combining the microbiological, chemical and the process engineering aspects of biological wastewater treatment systems.

R1 600 000
2014-2017

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

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

2472

This study evaluated the feasibility of using the Flow-Viz system to measure sludge rheology in-line to control polymer dosage and hence improve the dewatering efficiency in a belt filter press. The study found that there are significant variations in inflow sludge concentrations for the different plants influencing rheological parameters. However, pre-thickening at dissolved air flotation units delivered sludge with the lowest coefficient of variance compared to those without pre-thickening. The cake solids were found to be independent of feed sludge solids concentration. A unique relationship between process parameters, yield stress 100 cm on the belt and in the pipeline just after flocculation and the filtrate suspended solids was established for the first time. Further, it was established that the Flow-Viz system is capable of measuring variation in rheological parameters of poly-dosed inflow sludge as a function of process parameters. The Flow-Viz system showed great potential for improving the efficiency of wastewater plants and thereby reducing operating costs.

R860 000
2015-2017

Endocrine disrupting compound removal by wastewater treatment plants

Tshwane University of Technology; University of Pretoria

2474

The study screened EDCs in wastewater influent, and monitored, determined and mapped their removal using mass balance for commonly used wastewater treatment technologies (activated sludge, trickling filters & pond systems) in South Africa. Based on the screening of EDCs in influents, the EDCs could be classified into three groups, which included pharmaceuticals, oestrogens and perfluorinated chemicals, representing EDCs commonly found in South African wastewater influents. Through monitoring these EDC groups, their removal by specific treatment technologies during wastewater treatment has been mapped in terms of the influent load, percentage removal and effluent load. Generally, the influent and effluent daily mass loads followed a similar pattern; pharmaceuticals (300 g/dD; 225 g/dZ; 78 g/dPH) > oestrogens (5 g/dD; 15 g/dZ; 1.2 g/dPH) > perfluorinated chemicals (24 g/dD; 11 g/dZ; 0.4 g/dPH) and pharmaceuticals (130 g/dD; 47 g/dZ; 9 g/dPH) > oestrogens (4 g/dD; 8 g/dZ; 0.5 g/dPH) > perfluorinated chemicals 6.5 g/dD; 1.8 g/dZ; 0.1 g/dPH). The study further investigated laboratory-scale activated sludge and anaerobic digestion (AD) reactor systems to assess the fate of EDC groups under controlled conditions. Based on lab-scale AD data, and using the maximum application rate of 10 t/ha per year dry sludge, the study estimated that 7.0 kg/ha per year pharmaceuticals, 2.3 kg/ha per year perfluorinated

chemicals and 1.3 kg/ha per year oestrogens could be applied to agricultural land in cases where digested sludge is used in agriculture as a soil conditioner and fertilizer. This outcome therefore becomes a key decision-making aspect with regards to the use of wastewater sludge for agricultural purposes.

R550 000
2015-2017

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

VitaOne8 (Pty) Ltd

2626

This study assessed and quantified the extent of negative impacts on the proper functionality of sewerage systems (collection and conveyance systems) and wastewater treatment works (WWTW) resulting from drought and water conservation and demand management measures, and identified mitigation measures to minimise these impacts. A literature review of the impacts of reduced wastewater flows experienced internationally was conducted, while for a local context data from the City of Cape Town's nine WWTW that recently experienced reduced flows ranging from 17 to 52% was analysed, with findings and relevant information formulated into a guideline for use by municipal officials, to create awareness and assist with the implementation of mitigation measures regarding management of sewage conveyance and plant infrastructure performance.

R300 000
2017

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

Revision of Natsurv 10: Water and wastewater management in the tanning 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

Natsurv 10 is one of a series of national surveys on water use and wastewater management practices of industries in South Africa. The main aims of this revision were to: provide a detailed overview of the tanning and leather finishing industry in South Africa, and its changes since 1980; determine the water consumption and specific water consumption in the industry; determine wastewater generation and typical pollutant loads; and provide recommendations on best practices for the tanning industry. The range of specific water intake (SWI) for full tanning was found to be 170–550 L/hide (compared to 320–744 L/hide reported in the first Natsurv 10 (1989). A target SWI figure is proposed at 50–150 L/hide for wet-blue process stage, 100–200 L/hide for dye-house process stages, and 200–500 L/hide for total tanning and finishing stages. The effluent from tanneries contains high organic loads (as measured by chemical oxygen demand (COD)) and high concentrations of dissolved and suspended solids (as measured by total dissolved solids (TDS) and total suspended solids (TSS)). It also contains varying levels

of sulphates, sulphides, chlorides and chromium, which add to the pollutant load on the environment of the wastewater streams discharged. The specific pollutant loads generated by the different types and categories of tanning processes varies considerably for the main pollutants found in the wastewater streams (COD, TDS, TSS, sulphates, chlorides and chromium). Data on the quality of the wastewater (effluent) streams at the tanneries that were visited, and that were obtained from the tanneries themselves and from some of the municipalities to which the tanneries discharge their final effluent, are shown in Chapter 6. The specific pollutant loads calculated from this data are also shown, which indicates the considerable variation in ranges. The integrated wastewater treatment systems in the tanning and leather finishing industry consist of preliminary treatment (or pre-treatment), primary, secondary and tertiary treatment processes. Tanneries performing wet-blue re-tanning and leather finishing mainly use pre-treatment and primary treatment processes, whereas full house tanneries additionally use secondary treatment (biological treatment). Some tanneries in South Africa combine all effluent streams, while some keep separate effluent streams from the beamhouse and tanyard. The latter is preferable because organic waste is the major constituent of the beamhouse effluent, whereas the tanyard effluent contains high concentrations of inorganics, which could include chromium. Cleaner production technologies are continuously being researched, developed and applied for the tanning industry. A specific focus area is the reduction of salt loadings used in the processes. A number of recent cleaner production techniques are reported on in Chapter 8 of the report.

R900 000
2015-2017

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

The reports in this series quantify and explain the impacts of drought on agriculture, tourism, agro-processing, large and small businesses in urban areas and mining. Finally, we investigated the cross-sectoral impacts of drought on water quality. At the beginning of 2016, South Africa experienced severe droughts, which had an impact on the economy. For instance, the agriculture, forestry and fishing industry contracted for five consecutive quarters. The industry experienced a decline of 6.5% in the first quarter of 2016, which was mainly the result of decreases in the production of field crops and horticultural products. The electricity, gas and water industry contracted by 2.8%. Electricity generated and consumed both declined. Similarly, the amount of water distributed decreased, partly driven by drought conditions and water restrictions in certain parts of the country. Droughts have a significant impact on socio-economic, agricultural, and environmental spheres, and its effects are evident even in subsequent periods when precipitation occurs normally. Often, the economic impact of a drought is difficult to pinpoint because, unlike other natural disasters such as flooding, drought develops slowly and quietly, lacking highly visible and structural impacts for some time, meaning that developing drought conditions often go unnoticed until precipitation shortages become severe and impacts

begin to occur. A drought that directly hits the primary agriculture sector will have implications on primary and secondary sectors along its supply chain, such as seed supplier, agro-processors, supermarkets, or the bio-energy industry. Finally, the induced effect of a drought captures the impact on consumers and businesses further upstream and downstream. Thus, for example, a drought that hits the agriculture sector will impact on the welfare of maize consumers and of enterprises whose operations rely on output from the agro-processor (e.g. retailers). Drought requires short-term and long-run responsive actions. A country requires effective short-run drought mitigation policies to smooth production and consumption in the event of a drought shock. But, much more importantly, a country requires long-term socioeconomic resilience to future drought impacts, since mitigation and preparedness are keys to reducing future drought risks.

R600 000
2016-2017

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

Fate and behaviour of nano-TiO_2 nanoparticles in simulated textile wastewater

University of Johannesburg; Cape Peninsula University of Technology

2503

A thorough understanding of the fate and behaviour of engineered nanoparticles (ENPs) entering wastewater treatment systems is needed in order to predict and mitigate risks of ENPs affecting the treatment processes, and persisting through treatment to reach the natural environment via the treated water and/or solid residues. The specific aims for this study were (i) to monitor the fate and behaviour of titanium dioxide ENPs in a simulated wastewater treatment plant with respect to their physicochemical characteristics, (ii) to investigate chemical stability of titanium dioxide ENPs in wastewater and how they were affected by changes in pH, ionic strength, mono and divalent cations and natural organic matter content, and (iii) to establish possible mechanisms of titanium dioxide accumulation and/or degradation in wastewater sludge during wastewater treatment. Titanium dioxide ENPs were synthesized via the sol-gel method. Suspensions were prepared using deionized water (DI), monovalent cation electrolyte (NaCl) and divalent cation electrolytes ($CaCl_2$ and $MgCl_2$). Disperse dyestuff was used as a representation of natural organic matter (NOM) and the effects of the ENPs on an activated sludge reactor were assessed, as were the fates of the ENPs reporting to the treated effluent and the waste activated sludge (WAS). The addition of < 15 mg/L titanium dioxide ENPs had no effect on chemical oxygen demand removal, MLSS, or mixed liquor total plate count (TPC). The anatase ENPs remained unchanged during treatment. Removal of the ENPs from the influent was facilitated by sorption onto the activated sludge, as evinced by the presence of 90% of the added ENPs in the WAS.

R900 000
2015-2017

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 3: Minimising waste production

Treatment of mine water using a combination of coal fly ash and flocculants in a jet-loop reactor system

University of the Western Cape; CSIR; University of the Western Cape; Cape Peninsula University of Technology

2129

The generation of contaminated, sulphate-rich acid mine drainage (AMD) and waste coal fly ash are undesired by-products in coal mining and coal-fired power stations, respectively. Both are environmental liabilities. The need to remediate these problems has inspired the use of fly ash for the treatment of AMD. When fly ash is used to treat AMD, 80–98% of sulphate and most other pollutants can be removed in one step. This study demonstrated at 1 000 L pilot scale the treatment of AMD and circumneutral mine drainage to produce water that was suitable for drinking, agricultural or industrial use. Raw AMD from Lancaster mine and Matla fly ash were combined with small amounts of lime and aluminium hydroxide in the jet-loop reactor, and the concentrations of most toxic elements were decreased to within target water quality requirements. Sulphate decreased from 5 680 to 87 mg/L, the pH was raised from 2.26 to 8.8 and the electrical conductivity decreased from 6 880 to 14 µS/cm. Even after only 30 minutes' treatment with fly ash and lime the concentrations of priority elements (e.g. U and Th) were very significantly lower. Low traces of Sr (7.16 mg/L), As (0.55 mg/L) and Mo (0.84 mg/L) were the only elements that leached from the fly ash during treatment of AMD. The water recovery efficiency was 72%. The solids residue was suitable as a slurry or paste backfill material in terms of rheology, density, and shear; it showed typical Bingham plastic behaviour. The treatment of AMD with FA at 1 000 L pilot scale was successful, with 98.5% sulphate removal and water quality remediated to within DWS guidelines in one simple step using equipment with few moving parts. The treated water quality was suitable for agricultural and industrial purposes or it could be polished to potable quality by carbon dioxide sparging and ion exchange. This process circumvents the need for energetically and financially expensive membrane processes such as reverse osmosis. Many coal and other mining companies that are facing the problem of AMD management may find benefit using this fly ash based treatment in order to treat AMD in one simple step. Residues produced can be used to backfill mine voids in an integrated system and so prevent further AMD formation, offering a cradle to cradle solution. Backfilling will also prevent collapse of mine workings, prevent spontaneous combustion, enable better resource extraction and allow mine closure without long-term liabilities.

R2 560 600
2012-2017

Continuous eutectic freeze crystallization
University of Cape Town, Proxa (Pty) Ltd, University of the Western Cape; Cape Peninsula University of Technology
2229

A continuous EFC process is appropriate for the treatment of large volumes of brines since it allows better control of product quality, reduces waste and has fewer labour costs. The second aim of this work was to develop a continuous EFC process. To this end, a laboratory-size continuous EFC plant was designed and commissioned. It is essential that continuous solid solid-liquid separation is achieved in order to allow a smooth continuous EFC operation. This requires large ice and salt crystals which easily separate mechanically and, since product properties depend on the operating conditions, it is important to understand the effect of residence time and degree of undercooling on product characteristics. Further to this, large production rates are required at industrial process scale. This is sometimes limited by scale formation and a study focused on understanding dynamics around ice scale formation was conducted. The third aim was therefore to investigate the interaction between operating conditions and product quality, as well as operational constraints of a continuous EFC process. Since industrial brines contain more than one component, there is an opportunity to recover ice and more than one salt product. Although the treatment of such brines was proven using batch EFC, the use of continuous EFC would be beneficial for the treatment of large volumes of brines. Therefore, the fourth aim of this research was to investigate the treatment of real multicomponent brines using continuous EFC. Phosphonate-based anti-scalants were found to have a marginal effect on the thermodynamics of a Na_2SO_4-H_2O system but showed significant effects on the crystallisation kinetics of both ice and salts. This was mainly attributed to the alteration of the surface free energy and surface coverage. The continuous 2 L EFC plant was successfully commissioned and the crystalliser cooling capacity was found to be adequate for feed flow rates of 44 to 100 mL/min. Gravitational separation was achieved in the separation zones of the crystalliser. Increasing residence time at a constant operating temperature was found to enhance the mean crystal size of ice while increasing the degree of undercooling, at a constant residence time, increased the mean crystal size more significantly. The increase in size was attributed to more time for growth and faster growth rate, respectively. As expected, higher scraper speeds were found to delay the formation of an ice scale layer and the presence of impurities increased the induction time for scale formation. Ice and $Na_2SO_4{\cdot}10H_2O$ were produced from continuous EFC of ternary Na_2SO_4-$MgSO_4$-H_2O synthetic solutions using a non-scraped agitated crystalliser. It was found that increasing the concentration of $MgSO_4$ in the ternary Na_2SO_4-$MgSO_4$-H_2O depressed the eutectic temperatures for $Na_2SO_4{\cdot}10H_2O$ and ice crystallisation. A real brine was also treated using a continuous EFC process that employed a jacketed column crystalliser. Ice and $Na_2SO_4{\cdot}10H_2O$ were produced from this hypersaline brine but the production rates of both products varied widely at constant operating conditions. This was attributed to the coupled or interdependent crystallisation dynamics of the products in eutectic systems and short residence times in the column

crystalliser, which limited time for salt crystallisation in some runs. The ice product had a high Na impurity content but this reduced significantly after washing. Only traces of impurities were detected in the $Na_2SO_4 \cdot 10H_2O$ product but these could not be washed effectively.

R2 276 600
2013-2017

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, Imperial College London, University of Queensland

2389

Coal mining produces sulphide-containing ultrafine waste tailings which pose an acid rock drainage (ARD) generation risk. A two-stage froth flotation process developed at UCT aims to further process such wastes: the first stage produces a desulphurised, saleable coal concentrate and the second stage produces a low-volume, high-sulphide concentrate and a high-volume benign tailings which is safe for disposal without containment. Hampering the implementation of this treatment technique are: (i) the high cost of the oleic acid collector required in the first flotation stage, and (ii) the toxicity of the xanthate collector used in the second stage which presents issues with the final product stream handling and use. In this study, microorganisms and bioproducts were investigated as xanthate replacements. Potential microorganisms and bioproducts were identified, based on evidence that they are attracted to (attach/modify) surfaces, either coal or pyrite, the main sulphide mineral present in the coal wastes. All bioflotation options were required to be non-pathogenic and non-toxic. *Mycobacterium phlei*, raw algal lipids (RAL) and derived fatty acid methyl esters (FAME) were selected as potential coal bioflotation reagents. Eight micro-organisms were identified as potential pyrite bioflotation reagents. The performance of these bioflotation reagent options was tested using attachment experiments (for the microorganisms) and by monitoring surface charge changes, followed by batch flotation tests. The economics of producing a bioflotation and implementing reagent were examined by modifying the chemical system process flowsheet and financial analysis for the *M. phlei* example. *M. phlei* bioflotation (using current growth data and assuming on site production) was found to be more expensive than the chemical process. Thus, it is recommended that optimisation of *M. phlei* production is required before bioflotation implementation can be considered. The RAL or FAME options also require further investigation of large-scale production facilities before this option can be costed. In summary, technically competitive and non-toxic bioflotation options were successfully identified and demonstrated for both stages of the two-stage froth flotation process for the desulphurisation of ultrafine coal waste tailings, but a preliminary financial analysis showed that their production and usage results in a financially less attractive operation.

R1 247 513
2014-2017

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

University of the Western Cape; Cape Peninsula University of Technology

2391

Toxic metals are recalcitrant, inorganic pollutants and should not escape to the environment in wastewater. The ions of concern in this report are: Cr(VI) (carcinogenic), As(V) (lethal groundwater contamination), Sr(II) (radioactive by-product in nuclear power plants), Cd(II) (6th most poisonous substance both for humans and animals), Hg(II) (most Hg compounds are extremely toxic and can result in a perpetual destructive cycle), U(VI) (radioactive and extremely toxic). This study synthesised novel ligands for the selective extraction of radionuclides and toxic elements from mine water containing other metal ions and designed an ion exchange system that selectively removes radionuclides and toxic elements from mine water. The project has focused on three aspects, namely, the synthesis of selective ligands, the immobilisation of the ligands on silica/polymer supports and the applicability of the immobilised ligands for extraction of toxic metals. Two novel ligands were synthesised and separately two crown ether derivatives were all immobilised onto four different silica supports. These immobilised ligand systems were used to extract six different toxic metal and metalloid ions in water. The extraction capacities of the different immobilised ligands were compared so as to determine whether the substrates had any influence on the extraction capabilities of these ligands and it was shown that both the support and the type of ligand impacted upon the selectivity and removal capacity. This research also reports for the first time the fabrication of a combination of nanofibres prepared via electrospinning process followed by the immobilisation of a selective ligand on the nanofibres, namely 2-pyridine amidoxime (PyAMI) which was synthesised through the reaction between 2-pyridine carbonitrile and hydroxylamine hydrochloride. Electrospun PAN-nfs was used as support for PyAMI ligands to produce new adsorptive, PAN-PyAMI in non-woven mat format. The nanofibres have shown potential in adsorption of specific toxic metal contaminants from water and the nanofibre mats could be regenerated.

R765 362
2014-2017

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

In this study, analytical methods and procedures have been developed and/or optimized for the determination of total mercury and the speciation of inorganic and organic forms of mercury in different sample matrices such as water, sediments, and biota. These methods were successfully applied for analyses of environmental samples for ultra-trace mercury determination. Mercury is one of the most hazardous contaminants in the environment. The growing global concern over the release of mercury has prompted the preparation of country-specific inventories that quantify emissions from various sources. Mercury exists in the environment

in different chemical and physical forms with different behaviour in terms of transport and environmental effects. For toxicological and biogeochemical studies the total concentration of mercury is of little value without knowledge of its chemical forms. Thus, speciation of mercury is a critical determinant of its mobility, reactivity, and potential bioavailability in mercury-impacted regions. Understanding the movement and geochemistry of mercury from these regions is therefore necessary in order to predict the potential impacts and hazards associated with the mercury contamination. Risk assessment of mercury pollution in South Africa was based, until very recently, on total element concentrations only. It is necessary to evaluate mercury speciation under the country's semi-arid conditions, and characterize potential sources, pathways, receptors and sinks in order to implement mitigation strategies and minimize risk. The environmental pollution assessment was conducted within the Witwatersrand Basin, at four gold mining sites selected mainly for their mining history and from geophysical information obtained through satellite images. Sampling campaigns were performed during the dry and wet seasons. This study is a contribution to the assessment of the ecosystem impacted by mining operations in terms of mercury pollution since it presents, for the very first time, the problem of mercury pollution from gold mining operations in the general context of the Witwatersrand Basin, one of the biggest gold mining areas in the world. It also provides information on the mercury speciation, migration and fate in the region which can be used as a benchmark to understand the unknown transport patterns of mercury in a semi-arid environment.

R950 000
2014-2018

CURRENT PROJECTS

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.

R1 620 113
2013–2015

Revising the DWA guidelines on municipal tariffs for water services
Nelson Mandela 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.

R1 600 000
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).

R800 000
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 Metropolitan Municipality

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

R1 000 000
2012–2014

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.

R642 537
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.

R594 839
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.

R652 800
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 Metropolitan Municipality

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.

R500 000
2015–2017

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

R237 318
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

In 2016/17, Partners in Development were commissioned by the WRC to pilot the previously designed guidelines and management handbook in schools, in order to refine it and improve it based on the participants' experiences. The management programme involves three main actors at the school level, forming

a sanitation team: the principal, a selected teacher to serve as Health and Safety Manager (HSM), and the school cleaner or Health and Safety Officer (HSO). This team is in place to ensure a clear chain of accountability and communication from the HSO up to the principal and the SGB. The management model involves extensive training about roles and responsibilities, disease transmission, technical skills for cleaning toilets, and methods for reporting and monitoring work. The pilot programme was launched in 8 schools, following a selection process and renovations by the Department of Education. These schools were provided with supplies and regular support from the project team throughout the school year. In order to evaluate the success of the programme, the schools were visited on a regular basis, and interviews were conducted with the HSO, HSM, and principal every 1-2 months. Learners from each school were also interviewed half-way through the pilot programme and at the end of the programme. Supply inventory was also taken on a monthly basis, in order to provide insight into supplies usage in the programme and plan for subsequent deliveries. Each school in the pilot programme was evaluated as a separate case study, due to the varied experiences and environments at each. From these case studies, key themes were drawn out in an attempt to answer the key questions:

- What is vital to the management of school sanitation?
- What is beneficial to management of school sanitation?
- What are hindrances to management of school sanitation?

R1 000 000
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

R861 000
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

R893 900
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 Metropolitan University

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

R800 000
2016–2018

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.

R1 890 000
2014–2017

The Internet of things: opportunities for the WASH sector
CSIR
2779

Access to Water, Sanitation and Hygiene (WASH) services is an important mechanism to address the risk associated with the burden of disease. The use of information and communications technologies (ICTs) has been posited as one way of addressing the burden of disease and improving quality of life for those most at risk. One of the new developments in ICT, the 'Internet of Things' (IoT), allows for the integration of the digital and physical worlds, resulting in the creation of new services that can be deployed for positive impact, including in the WASH context. Innovative IoT work, including technology development and applications, is being done in relation to WASH services in both the developed

and developing world context. The study will report on the opportunities within the WASH service provision context and link these opportunities to the challenges (both technological as well as contextual). Furthermore, the study will highlight success as well as failures in the application of IoT in a WASH context. Finally, it will present a future view and recommendations into the application of IoT in a WASH context.

R300 000
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)

R2 000 000
2016–2019

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Solar energy for desalination and water purification

University of Pretoria

2467

South Africa has some of the highest solar fluxes on earth, making solar energy a prime candidate for renewable energy generation in this country; however, energy only forms one part of the water–energy–food nexus. Thus, if South Africa is to achieve water, food and energy security, it is important to pay attention to the overlap between these areas and look for ways to exploit possible synergies. This study focuses on the water–energy nexus by investigating the use of direct solar energy for driving water desalination instead of using renewable energy to generate electricity to drive it. This study will investigate the use of graphitic foams or carbon black as a solar collector. The use of carbon black is unique in the sense that it uses an entirely new design where the lens is stationary and a mirror tracks the sun. This has never been attempted before

as demonstrated by a recent review of Fresnel lens applications from 1950 until now. The data generated will prove invaluable in determining the feasibility of application of the proposed distillation schemes, as well as uncovering potential stumbling blocks for large-scale implementation.

R500 000
2015–2017

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

Due to a growing water-scarcity problem, alternative sources of water are being explored to satisfy demand. For example, eThekwini Municipality is in the planning stages to obtain potable water from the recycling of wastewater as well as from desalination, while in Gauteng the reclamation of mine water is being considered. This study will investigate the environmental impacts of these three technologies by employing a life-cycle assessment approach. Such a study is useful and necessary in order to effectively summarise and provide information regarding focus areas with the highest environmental burdens of these technologies in order to improve them environmentally and to assist in the future design of such water treatment plants in the country. Specific objectives of the project include: generating environmental information by investigating each of the water treatment technologies (desalination, recycling of wastewater and reclamation of mine water); improving the overall environmental performance of these processes, and providing guidance on potential life-cycle environmental consequences of the selected technologies.

R200 000
2016–2018

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

Unisa (Florida); ARC Animal Production Institute

2568

Drinking water sources contain different kinds of potentially pathogenic pollutants like viruses, bacteria, protozoa and fungi. Drinking water contaminated with fungi is becoming of increasing importance due to increasing numbers of immunocompromised individuals. Fungal contamination of drinking water is associated with taste and odour problems. Currently, drinking water contamination with fungi receives considerably minimal attention and may be considered to be an underestimated problem as it is not currently monitored. Thus, the main aim of this study is to collect treated drinking water samples and determine the densities of fungi (both pathogenic and non-pathogenic) and total & faecal coliforms, and also to determine the presence of traces of different types of mycotoxins in treated drinking water. Based on the findings, the study will formulate recommendations for monitoring and regulation of fungi in final (treated) drinking water.

R600 000
2016–2019

Framing desalination within the water–energy–climate nexus

EScience Associates (Pty) Ltd; University of Cape Town

2778

Seawater desalination has been identified as one of the strategies for achieving water security in South Africa. The current drought crisis and plans for large-scale desalination present an opportunity for integrating water, energy and climate change aspects in desalination planning and decision making. The ability to systematically balance the relationships between water, energy and climate change can contribute to the increased sustainability and resilience of desalination as a water supply option. Integrated water–energy models and scenarios can be used to inform decisions with respect to preferred or appropriate technology, assessment of alternative scenarios, as well as relevant planning and other decisions made by energy, water and other stakeholders. The proposed study aims to establish an understanding of desalination within the water–energy–climate nexus; clarify the role of desalination with or without drought; explore opportunities for achieving water–energy–climate change security in the context of desalination and identify knowledge and policy gaps that exist.

R300 000
2017–2018

Programme 3: Drinking water quality

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.

R600 000
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.

R1 000 000
2015–2018

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

Antibiotic resistant bacteria (ARB) and antibiotic resistant determinants (ARDs) are major emerging public health threats. Available data sets on antibiotic resistant bacteria, resistance and virulence genes are mainly based on culture dependent methodologies. These are time consuming methods and protocols take several days to weeks to complete. However, new molecular detection methodologies and next generation sequencing may provide further insights into the selection, accumulation and spread of ARBs, ARGs and virulence genes. The overall goal of this proposal is to establish methodologies to monitor the dynamics of antibiotic resistant bacteria and genes in raw and drinking water in selected water production facilities and associated drinking water distribution systems. Data will be evaluated against the background of the implications it may have for current water production practices and the relationship that exist between source water and such facilities. Furthermore, such data will have implications for future water quality monitoring practices. In addition, the data will also be useful for future decisions regarding available water re-use strategies and thus address light-houses in fresh-water governance.

R1 526 000
2016–2019

A scoping study on microplastics in water environments

North-West University (Potchefstroom)

2610

Plastic and microplastic pollution, along with related nanoparticles are an issue of ‘emerging’ concern. Plastic pollution in the marine environment is well documented, however, there are few studies on the extent of pollution in freshwater and treated water sources. This project is a scoping study to test relevant methods for sampling and detection of microplastics in water, and to apply these methods for determining typical levels of microplastics in raw (surface and groundwater) and treated (drinking) water sources. Based on the results, potential threats to human health and biota will be evaluated. In addition, priority plans of action for research and policy for South Africa will be identified, as well as possible and potential mitigating actions.

R300 000
2016–2017

Programme 4: Water distribution and distribution systems

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.

R700 000
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.

R520 000
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.

R900 000
2015–2018

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

R300 000
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

R1 335 000
2016–2019

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

University of Cape Town

2573

Water quality deterioration due to contaminant intrusion events in water distribution systems has been linked to a significant proportion of the burden of waterborne and water-related illness in South Africa. The prime objective of this study will be to establish the frequency and causes of contamination intrusions in water distribution systems, as well as the characteristics of the distribution system that contribute to these events. In addition, this study aims to provide guidance on best practices of water quality control in water distribution systems using the Water Safety Plan (WSP) as a framework. The outcome of the study will provide guidance to the planning, design, operation and maintenance of water distribution systems with the purpose of controlling intrusions, thus controlling the level of deterioration of water quality and reducing public health risks.

R750 000
2016–2018

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.

R998 950
2008–2010

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.

R3 000 000
2011–2016

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

City of Cape Town Metropolitan Municipality; University of the Western Cape

2413

The research study aims to create a community of practice (CoP) with all relevant stakeholders who together with research partners test the concepts, framework and options of water sensitive (urban) design. This will be achieved by way of an interactive process that permits those who have any interest at all to participate in the design process, thereby acting as change agents in the strengthening of practice and theory. In its initial stages the CoP programme will need to be nurtured in order to encourage participation, but in the long term (and hopefully with further external financial support) it is envisaged that the CoP will have regional clusters of interested players throughout South Africa engaging in new forms of leadership and driven by champions in WSD. The study anticipates contributing to the development of knowledge and understanding by: (i) demonstrating the positive influence of coordinating bodies (such as Learning Alliances) and ‘champions’ in terms of raising awareness about WSD and facilitating change; (ii) generating strategic evidence of how WSD implementation projects might and do create new efficiencies, as well as a new understanding about innovative practices and reflexive learning within WSD; (iii) developing knowledge connected to policy development and change to influence planning and

design; (iv) developing an understanding of how to transform apartheid settlements in which the integration of water resources (blue-green infrastructure and ecological infrastructure) becomes fundamental to their design.

R2 500 000
2014–2019

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

University of Johannesburg; Vaal University of Technology

2563

This project is a follow-up to completed project K5/2116//3 titled 'Analytical strategies for monitoring heavy metals removal in selected wastewater treatment works and constructed wetlands in Gauteng and KwaZulu-Natal Provinces'. Based on recommendations by Reference Group members on the need to conduct mass balance studies for trace metals within wastewater treatment plants (WWTPs), the current study was motivated for. The purpose of the study is therefore to analyse and evaluate mass balance for the heavy metals in Gauteng WWTPs as a way of understanding the transport, fate and behaviour of these metals during each treatment stage. This will enable better understanding of each treatment unit and henceforth improved analytical strategies for heavy metal monitoring and removal. The study targets selected wastewater treatment plants in Gauteng Province. The final report from the project will serve as basis for decision making regarding any need for incorporation of additional treatment steps within the current WWTP configuration.

R995 000
2016–2019

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

Durban University of Technology; Columbia University

2565

The major challenge affecting the performance of wastewater treatment processes is efficient and cost-effective removal of nitrogenous compounds, especially ammonia. Current biological nutrient removal systems involve a two-stage process, i.e., nitrification and denitrification, which is energy intensive; produces excessive sludge and releases significant amounts of greenhouse gases such as CO_2, N_2O and ozone depleting NO, which cannot objectively be considered as a sustainable process. Developing a more efficient and cost-effective bioprocess technology for the removal of nitrogenous compounds from wastewater treatment facilities therefore will be of great interest for proper sewage management in South Africa. The proposed project thus aims at devising a suitable Nitritation-Anammox reactor and optimization for long-

term stable operation to provide an alternate bioprocess technology for the treatment of nitrogen/ammonium-rich wastewater. Most of the current Nitritation-Anammox reactors worldwide are single-stage reactors, where it is difficult to maintain the optimum conditions required for the growth of two metabolically diverse group of organisms in a single reactor, which makes the process prone to system failures. The proposed two-stage Nitritation-Anammox reactor has the potential to overcome the above challenge by providing specific growth conditions by separating them into two separate reactors with the potential for long-term stable performance. The purpose of this study is therefore essentially to improve the performance of the conventional single-stage Anammox process by developing a two-stage Nitritation-Anammox process for enhanced process control.

R1 850 000
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

In order to predict both activated sludge (AS) and anaerobic digestion (AD) performance, different organics, such as food waste, industrial organic wastewaters, sewage sludge, agricultural wastes and manures, the organic fraction of municipal solid waste and different settling velocity groups in primary sludge will be collected and tested for biodegradability and composition in the Augmented Bio-methane Potential Test (ABMP), and in parallel in the Augmented Bio-sulphide Potential (ABSP) test, both to be developed in this project. Both methods will be applied for testing the apparatus and procedure to determine unbiodegradable fraction and hydrolysis rate and composition of the biodegradable organics of different settling velocity groups in municipal wastewater with only routine and simple aqueous phase measurements. A fully integrated physical, chemical and biological processes anaerobic digester (AD) simulation model to simulate the BMP batch test conditions will be developed in WEST, with coding of PST model to predict higher removals of unbiodegradable organics (60–80%) than biodegradable organics (40–60%). The PST model will be included 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 AS and AD system performance in plant-wide WWTPs.

R1 800 000
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

This project investigated the potential of BSFL (Black Solder Fly larvae) for effective digestion of faecal sludge from urine diversion dehydrating toilets (UDDT) for possible application as fertilizer for agricultural purposes. For this study, the urine and faecal fractions from UDDTs were collected. Black soldier fly (BSF) technology was used to treat the faecal matter. Different composites were created using food waste, poultry feed and bagasse. BSF larvae growth, nutrient content, bacterial and phage inactivation during drying and moisture content were monitored before and after processing. Overall it was observed that there was nutrient increase, significant increase in larvae biomass and reduction in microbial content after the study. The results from the struvite study revealed that cross-contamination was occurring in UDDT toilets, that is, faecal matter was entering through the urinal section. Recommendations were made based on the study on how urine and faecal sludge could be used as fertilizers. Results from this study revealed that the faecal sludge was supportive of the growth of the BSFL and significant reduction in bacterial pathogens was tested. Further educational campaigns would be required for UDDTs to limit cross contamination.

R328 000
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

South Africa is a water-scarce country, with about 65% of the country receiving an average annual rainfall of less than 500 mm, which is normally considered to be the minimum for rain-fed agriculture. South Africa has approximately 2.2 million food-insecure households, amounting to approximately 14 million individuals, who spend more than 60% of their income on food and who are vulnerable to food price increases. In this regard the South African Government has adopted a policy of ‘one house; one food garden’. This policy entails needing water for the irrigation of food gardens, which is often difficult to obtain for poor households. Greywater is a potential alternative source of water for small-scale agriculture such as household food gardens. It is available on a daily basis from regular household activities such as bathing and laundry, and in addition also contains low levels of nutrients, which may be beneficial to poor households who cannot afford to purchase fertilizer. However, greywater also contains constituents which can be harmful to soil and to plants,

particularly sodium salts and surfactants. The content of these constituents varies among different sources of greywater; thus the source of greywater is a major factor in determining its suitability for use for irrigation. While studies investigating the composition of greywater and the growth of plants irrigated with greywater exist, both components are not usually addressed in the same investigation. This study therefore aims to provide some clarity on this to better assist policymakers, NGOs, municipalities and small-scale food gardeners to improve food security in poor households.

R345 000
2016–2018

Programme 3: Stormwater and sewerage systems

Sanitation technology assessment and evaluation

Partners in Development (Pty) Ltd

2414

Project aims:

- Develop a sanitation technology assessment and 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

R1 315 600
2014–2015

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

University of Cape Town; City of Cape Town Metropolitan Municipality

2569

This research aims to provide improved design specs for community ablution blocks (CABs). This information is of high value especially since CABs are beginning to be installed in the City of Cape Town. The end product developed will also provide guidance or designing CABs.

R910 000
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

The recently enacted Spatial Planning and Land Use Management Act of 2013 (SPLUMA), which came into effect on 1 July 2015, will radically change planning in South Africa. In the past, town planning practices (spatial development frameworks and land use schemes) were limited to former town boundaries (excluding the rural and traditional areas). Today, the Act is used to establish planning as a municipal competence and compels municipalities to compile wall-to-wall Spatial Development Framework (SDF) and Land Use Schemes (LUS) within 5 years of implementation of the Act.

Rural areas have resources that are unique from the urban areas that give them a comparative advantage; however, the exclusion of rural areas from municipal planning and incoherent development approaches has made rural areas to be seen as hopeless areas where growth and development can never happen. Another problem identified is that land use planning in urban and rural areas has often been divorced from infrastructure planning (e.g. water) due to fragmented silo-management, to the detriment of sustainable settlements. The result is that planning for water supply and planning for water demand (as expressed through population and land use growth) becomes disconnected. The complexity and interdependence of the issues and challenges related to unsustainable development can only, however, be effectively addressed if a strategic framework for sustainable development is employed in spatial planning. One of the key principles of SPLUMA is the active pursuit of sustainability through the promotion of integrated planning and the involvement of various sector departments (water) in formulating planning documents (SDF & LUS) at various levels of government (municipal). In order to plan sustainably, spatial planning and land use management systems must consider all current and future challenges such as demographic, environmental, economic, social, spatial and institutional challenges, in order to foster sustainable development within urban and rural areas. This project aims to identify the gaps between spatial planning and water management at local government level in a Category B municipality, using Mogalakwena Local Municipality as a case study. The study will therefore develop a Water Sensitive Spatial Development Framework (WS-SDF) and the Water Sensitive Land Use Scheme (WS-LUS) within the legal requirements of SPLUMA and influenced by innovative water management practices. The WS-SDF and WS-LUS will address all the elements of water-conscious land-use planning from inception phase to the implementation phase, and will be adopted and implemented by the municipal council as the primary spatial development decision making and land use management tool.

R2 000 000
2016–2019

Assessment and control of inappropriate discharges into storm drains
Cape Peninsula University of Technology; City of Cape Town Metropolitan Municipality
2600

The aim of the project is to assess the extent of the inappropriate discharge problems, in two case studies, and develop procedures to select the most appropriate and cost-effective strategies to find, fix and prevent these inappropriate discharges. This will be approached on the basis of water sensitive urban design (WSUD), which ensures 'urban design' is undertaken in a 'water-sensitive' manner". This urban management entails the operational and maintenance aspects, community awareness building and education, optimization of the use of resources, and the identification of infrastructure needs. One of the key impacts expected from this research study is promoting healthy urban waterways and sustaining natural ecosystems; and this is at the heart of WSUD, which emphasizes ecologically sustainable development. In short, this study will fall

under the Urban Water Infrastructure component of WSUD activities; and related to the sub-components of stormwater management and wastewater/sanitation minimization.

R1 202 439
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

Anaerobic sludge digestion and mechanical sludge dewatering are currently the preferred sludge handling approaches at many of South Africa's larger municipal wastewater treatment works. This approach has beneficial generation of biogas via the anaerobic sludge digestion process, with the biogas used as a fuel source for heating, electricity generation or converted to a reusable green fuel. However, such a sludge-handling approach generates return streams that are typically recycled back to the head of the WWTWs where the liquid passes back through the 'water line' of the works. These return flows contain a significant concentration of nutrient loads (phosphorus, nitrogen and ammonium) which are released to the water phase during the sludge treatment processes, placing a strain on nutrient removal within the treatment system, thereby overloading the treatment system and creating effluent quality issues. It is therefore beneficial to treat the return flows separately and this treatment is facilitated by the concentrated nature of the return flows, i.e., small flows but high concentrations. This study therefore proposes to investigate the effects of sludge return liquors on treatment plant performance in South Africa. Furthermore, the development of a tool to assess the impacts of these return liquors is also proposed. Potential treatment solutions for the South African wastewater treatment industry, including looking at the viability of resource recovery within the South African context will be explored and identified.

R1 360 000
2016–2019

Programme 5: Sanitation technology and innovations

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

Partners in Development

1887

Although there are powerful social and political aspirations for full waterborne sanitation in South Africa, cost, water scarcity and the technical challenges encountered in rural areas as well as some peri-urban areas have not made this a viable option in terms of government service provision. There is a need, therefore,

to explore and develop a range of options that bridge the gap between standard RDP dry onsite sanitation systems and full waterborne sanitation. Pour flush designs offer the benefits of flushing excreta past a water seal while not requiring connection to reticulated water or sewerage systems. This research study aims to create an understanding of the technical, social and environmental challenges associated with pour flush technology. The specific aims are to:

- Establish what is the current best practice for pour flush sanitation in South East Asia, where it is widely applied
- Establish which existing South African sanitation technologies most closely approximate pour flush and the operational history of these technologies
- Produce a design for a South African pour flush latrine
- Test the pour flush design in a suitable community; monitor its technical, operational and social viability
- Establish linkages between pour flush technology and water supply/grey water disposal

R1 000 000
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.

R1 475 175
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.

R500 000
2013–2015

Eastern Cape school sanitation – pour flush pilot
Maluti GSM
2444

WRC project K5/1887 has seen the development of the pour flush toilet, suitable for use in South Africa, and subsequently manufacturers have been working on the manufacture of pour flush and low flush latrines. The arrival of this technology presents the opportunity for widespread access to a flushable toilet that can be used in areas not connected to sewers. Because the latrines only use one to two litres of water per flush, they are suitable for using in areas where there is limited water supply, specifically areas with communal tap-stands, and can even be flushed using greywater. The pour flush technology could potentially significantly improve the quality of school sanitation facilities in rural areas and the objective of this pilot project is to test the technology in this environment. In this project, five sanitation blocks containing the pour flush innovation were installed in the Eastern Cape Province in consultation with the Department of Education (Eastern Cape) and the Department of Science & Technology. Feedback from users indicated that it is an improvement over pit latrines and does not smell. Sludge can been relatively free of detritus and is therefore more conducive to emptying.

R372 100
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.

R1 454 486
2015–2018

Performance assessment of DEWATS constructed wetlands

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

2579

eThekwini Water and Sanitation (EWS) has identified a sewer boundary outside of which it is currently too costly to extend the existing conventional sewer network. In order to provide desirable flush toilets to the planned social housing developments that fall outside this sewered area, only onsite wastewater treatment options are viable. Several existing social housing developments have been constructed in eThekwini with individual household septic tanks for wastewater treatment. The septic tanks have proved problematic for social housing, as they require large areas for the evapotranspiration areas, greatly reducing housing density. Further, many residents are unaware of the necessity of the evapotranspiration area and have constructed ancillary buildings on the plots, increasing the demand on the systems and disturbing the evapotranspiration process. The result is failing septic tank systems and untreated wastewater being released into the community and the environment. DEWATS systems constructed within a community would allow for flush toilets and a low-maintenance wastewater treatment solution, while maximizing housing density. Another proposed application of DEWATS is to treat wastewater from community ablution blocks (CABs) located outside the sewered area. EWS has identified more than 200 such informal settlements that could benefit from DEWATS plants to treat wastewater from CABs. The current best sanitation option for these communities is the installation of a CAB with treatment being provided by a DEWATS system followed by a constructed wetland. This project investigates the performance of the constructed wetlands so as to guide the rapid roll-out of CABs (and associated treatment systems) in the more rural areas of Durban.

R994 500
2016–2019

Drying and pasteurization of faecal sludge using solar thermal energy

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

2582

In South Africa, the emptying of latrines is usually performed using manual labour. The collected sludge is then transferred to landfill or, in rural areas, buried in trenches. The latter technique is technically challenging in urbanised spaces where space is limited. This has led to a significant investment in the development of technologies – known technically as faecal sludge treatment processors (FSTPs) – designed to treat faecal sludges at decentralised locations. An example of this, is the Latrine Dehydration and Pasteurisation (LaDePa) machine developed in Durban; a containerised solution that, as the name indicates, dries and pasteurises faecal sludge. In 2016, the WRC-funded study led by the Pollution Research Group, University of KwaZulu-Natal, sought to optimise the LaDePa process. The

study generated valuable information of the drying rates of faecal sludge, specific to infra-red treatment. Drying represents a critical process for the treatment load of faecal sludge. The loss of moisture leads to the decrease of the mass and volume of the material reducing costs related to transportation and storage. The reduction of the pathogen load leads to a lower risk during handling. Drying can be the final treatment before reuse or a pre-treatment step before further processing (example: pyrolysis or combustion). As an extension of the above work, WRC Research Project K5/2582 was initiated to expand on the knowledge base gained from the LaDePa project by investigating solar drying and understanding the kinetics involved in the process as means to pre-treat faecal sludge. In the faecal sludge sector, the use of solar energy for drying has been minimal, with only a few cases. Possible reasons for the low use of solar drying is the lack of awareness about this type of technology, as well as a lack of knowledge and data for the design of plants that could dissuade sanitation practitioners from using solar drying technologies. Motivated by these gaps, a fundamental study was conducted in this project to characterize faecal sludge solar drying. The data obtained during the project could be used for the design of solar drying plants, improvement of existing technologies and innovation of further ones. This study developed a thermobalance to measure the kinetics and calculate the energy balance during solar drying at different conditions, information which is crucial for the design and development of solar driers.

R657 000
2016–2018

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

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)

R750 000
2013–2016

Programme 2: Integrated management

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.

R900 000
2015–2017

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)

R1 368 000
2017–2019

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.

R1 400 000
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.

R700 000
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.

R306 000
2014–2015

Brine systems and treatment processes

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

2576

Brine systems and treatment processes
University of Cape Town; Eskom; Environmental and Nanosciences Research Group; University of Istanbul
2576

As water legislation is tightened and access to fresh water restricted, the treatment of wastewater to recover pure water is becoming increasingly important. Reverse osmosis is an effective and economical technology for water recycling and recovery. Therefore, as the cost of reverse osmosis decreases, more desalination and membrane processes are being implemented. 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

R2 004 283
2016–2019

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.

R400 000
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

R850 000
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.

R1 000 000
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.

R1 200 000
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.

R2 421 875
2015–2019

Photo-PROTEA

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

2562

Waste effluents produced by wineries and especially olive-mills are highly toxic for the environment, exhibiting phytotoxicity and anti-microbial activities, mainly due to polyphenols contained in the residual waters. These contaminated effluents cannot be treated in conventional wastewater treatment facilities due to their general toxicity towards microorganisms; therefore, safe ways for disposal need to be developed and implemented despite the lack of legislation worldwide. Collection and storage in large evaporation basins or ponds result in heavily charged residues that still need to be decontaminated before using them as fertilizer or digestion in bioreactors. This solution also requires vast areas of useful land while producing malodorous vapours. Sophisticated processes are suitable for phenol detoxification but remain impracticable for large volumes and are not economically and technologically feasible. Despite bacterial toxicity, bioremediation with microorganisms can be achieved with moderately loaded winery wastes; for example, in constructed wetlands; suitably selected microbial communities represent a promising route towards low-cost, easy-to-operate bioprocesses for the remediation of phenol-contaminated wastes from wineries and olive-mills. Another existing bioremediation process has been developed in Europe for pesticide-contaminated

agricultural wastewaters based on photosynthetic bacteria. This process, called LIFE-Phytobarre, was developed by the French partner, who is listed as a co-investigator in this proposal. LIFE-Phytobarre is currently employed specifically for the treatment of waters contaminated with phytosanitary products during the washing step of the machinery used in agriculture for crop phytosanitary treatments. For this project we aim to adapt the process for the treatment of wine and olive oil wastes.

R700 000
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

R160 000
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

Attractive opportunities exist within the South African industry to recover large volumes of water from industrial waste streams, while simultaneously generating significant amounts of biofuels. As a water-scarce country, fresh water resources in South Africa are constrained, leading to competition for water between human use and alternative applications, thereby limiting industrial and agricultural expansion. Recovery and re-use of water locked up in industrial waste streams is therefore of paramount importance to ensure optimal utilisation of a scarce natural resource, specifically for re-utilisation in industrial and agricultural processes.

R1 000 000
2016–2019

Water recovery from flue gas evaluation

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

2571

The introduction of the Minimum Emission Standard (MES), and specifically compliance to sulphur dioxide (SO_2) emissions with the employment of commercially proven technologies of wet and semi-dry flue gas desulphurization (FGD), increases the water consumption of a conventional dry-cooled coal-fired power generation plant. FGD installations are designed to cause an intensified contact between flue gas and aqueous-based absorbents. As a result, most of the SO_2 is removed from the flue gas. However, during the process the relative humidity of the flue gas increases. Installation of FDG increased the total water consumption of the power plant by 100 to 200%. The development of flue gas water recovery technologies could potentially mitigate this loss. This project aims to evaluate the demonstration of the techno-economic viability of advanced membranes on a pilot scale using flue gas from one of South Africa's power stations. In addition, the potting technology required to put these membranes into membrane modules will also be investigated. The rationale for the local development of membrane modules is that 85% of the cost of a module is in the module making and not in the membrane itself. 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

R3 670 000
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

R550 000
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

R900 000
2016–2019

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

Acid rock drainage (ARD) is well recognized as a significant problem in South Africa. Oxidation of sulphidic minerals results in acidic sulphate products which cause increased salinity and acidity of water run-off, leachate and water bodies, mobilization of heavy

metals and contamination of the environment. Following mining of sulphide-bearing ores, the generation of ARD becomes a problem of longevity, extending for 10s to 100s of years after mine closure; hence it is important to handle waste materials and their disposal to prevent or minimize the generation of ARD. Formation of ARD requires the reaction of a combination of sulphide, water and oxygen and is often catalysed by micro-organisms. Hence, the long-term prevention of its formation requires the removal of these components from the reaction surface. Most typically, exclusion of oxygen and water is sought; however, this is required on an ongoing basis. Conversely removal of sulphide presents a permanent solution in which the risk of ARD formation is completely removed. This is the preferred approach in this project. The aims of the project are as follows:

- 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

R2 565 000
2013–2017

Irrigation with poor quality mine water in Mpumalanga

University of Pretoria; University of the Free State (IGS)

2564

As a result of Mpumalanga's erratic rainfall, this region is highly dependent on irrigation to produce crops economically. In cases where the mine water from operating and closed coal mines is of too poor a quality to discharge into rivers, reverse osmosis is often considered as a means of treating this water. Reverse osmosis is an energy intensive and expensive process with a high carbon footprint. The generation of electricity for this process has additional environmental impacts and leads to the need for more mining. Using mine water for irrigation, therefore, potentially represents a more sustainable and economically feasible treatment approach with a lower carbon footprint, and, even more importantly, represents a productive use of this water that can benefit local communities that can no longer rely on mining for an income. It has been estimated that eventually 20 000 ha can be irrigated with coal mine water in the Mpumalanga region. Due to the large scale at which irrigation with mine water could be practised in Mpumalanga, together with the need for information regarding the fate of the solutes added with the irrigation water, there is currently some concern by the Department of Water and Sanitation in allowing this to take place using significant amounts of saline mine water. Modelling can provide glimpses into the future and insights into the causes of changes detected by monitoring as well as the testing of different 'what if?' scenarios. This work aims to provide the necessary data, using state-of-the-art techniques – from

plot to catchment scale modelling and monitoring to illustrate the quantification of water and salt balances for catchments where large-scale mine water irrigation may be proposed. It is envisaged that this information will play a key role in assisting DWS to reduce risks with deciding where mine water irrigation can take place responsibly, and at what scale. In addition, guidance with respect to monitoring requirements and thresholds for action will be forthcoming.

R6 200 000
2016–2021

Programme 3: Minimising waste production

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.

R1 795 960
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.

R2 372 862
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.

R1 754 440
2014–2018

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

Open-pit mining results in pits, overburden or waste rock piles, and sometimes slimes impoundments remaining on the landscape. The excavated pits are of various depths and sizes, but all require environmental reclamation. One possible reclamation strategy could be the creation of pit lakes at the end of mining. Pit lakes are formed by water filling the open pit left upon the completion of mining operations. These pits can be filled by artificial flooding or allowing the pits to fill through natural hydrological processes such as precipitation, surface runoff or groundwater rebound. A large number of opencast mining operations in South Africa have left a final void when mining was decommissioned. This is the result of various reasons; from the lack of sufficient material to fill the void to financial reasons or a lack of a proper closure plan. Some voids are filled partially with backfill material. These voids are internationally referred to as pit lakes and have been studied extensively in Europe, Australia and America. However, very little work has been done on coal mine pit lakes in South Africa.

The aims of this project are as follows:

- 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

R1 240 350
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

The primary metal production and coal-based power generation industries produce large tonnages of solid waste (including tailings, waste rock and overburden) which pose a significant and irreversible risk to the surrounding environment, and frequently also represent a long-term economic burden and loss of valuable resources. It is becoming increasingly recognised that conventional waste disposal techniques are inadequate in addressing the potential risks associated with biodiversity losses, degradation and consumption of natural resources such as land and water, as well as health and socio-economic impacts on local communities. Changes in legislation and global thinking have prompted a growing trend towards the development of waste management approaches that remove these risks in perpetuity, whilst simultaneously providing opportunities for value recovery and re-allocation of unavoidable wastes as feedstock for other uses. The aims of this project are as follows:

- 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

R1 277 837
2016–2018

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.

R2 800 000
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.

R2 800 000
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.

R2 800 000
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.

R2 800 000
2015–2016

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

University of the Witwatersrand; CANSA; Impala Platinum Ltd

2589

Membrane distillation (MD) is a thermally driven separation process that only allows vapour molecules to be transported across a hydrophobic membrane. Therefore, MD can be used to concentrate a stream to the desired concentration. Many researchers have investigated the use of MD for the treatment of various industrial wastewater streams but the application of MD to the treatment of mine wastewaters is rare. Some research has been done on the influence of high concentrations on the efficiency of the MD process; however, this was mainly based on generic solutions and not on actual brine produced from mining activities. The development of an MD process also requires better crystalliser control strategies, since most MD research is based on a batch process, thereby limiting the crystalliser control. Another key area in MD that currently needs research, is the influence of the membrane type and its characteristics on the flux through the membrane, as well as the fouling rate on the membrane. Furthermore, the fouling potential of certain membranes may vary according to the water that is being treated,

with some membranes possibly being more applicable to specific wastewaters. A previous WRC project (K5/2223/3) has shown how the temperature and concentrations of the feed and product solutions affect the flux through the membrane; however, the effect of the membrane characteristics on the flux and fouling potential was lacking. Furthermore, results from K5/2223/3 indicated that fluxes of up to 65 L/m2.hr could be achieved, which is up to 3 times higher than what has been found in literature to date and therefore indicates a definite possibility that membrane distillation has a great potential to be used to increase water recovery from RO brines whilst generating usable salts as a by-product. This project therefore aims to follow on from K5/2223/3 and investigate the applicability of MD for the treatment of industrial wastewater, with a specific focus on how the membrane characteristics affect the flux and fouling potential of the membrane. The project will also focus on looking at actual industrial mine wastewater in South Africa, with an emphasis on the most suitable membrane types for specific types of wastewater towards providing industrial technology suppliers and practitioners with valuable, readily usable information. Ultimately, this project could offer a more energy efficient and sustainable industrial wastewater treatment process that reduces wastewater production, for which there is a major technological gap in providing a cost-effective brine treatment solution towards achieving zero liquid discharge.

R862 250
2016–2019

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

R500 000
2014–2016

NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Water demand forecasts for infrastructure development and water conservation at local municipality level

Conningarth Economists

2724

Aims:

- To develop a water demand forecast for South Africa on detailed water usage areas and also to balance the forecasted demand with the current supply of water in selected case study areas
- To project (short, medium and long term) the water demand for various local municipalities. These forecasts can subsequently be aggregated into larger water usage areas such as provinces, metropoles, water management areas, catchment management areas, etc.
- To conduct a full water balance for different water usage areas. It is proposed that the case study areas be selected in such a way that they exhibit a single local municipality, a water board that supplies water to more than one local municipality and a specific water management area

R570 000
2017-2019

Testing the acceptability of urinals among girls and women in South Africa

Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg)

2735

Urinals are sometimes used to reduce the number of toilets required at a school, which typically reduces the cost per child served. Urinals can also reduce queues for school toilets and the need for small learners to use pit toilets that are not suitable for them. Urinals for girls and women have been used with success in some countries, are easy for young children to use, and are cheaper and faster to build than toilets. For younger children, using urinals for urinating may be easier, cleaner and safer than using pedestals, where they may have to use their hands to lift themselves onto a soiled toilet seat. For older children, defaecating may happen only rarely at school and the primary need for a toilet may be for urination. Where school facilities are inadequate it may be possible to add urinals more cheaply and quickly as an interim measure while resources are collected for improving toilets. This study demonstrates the potential for acceptance of the introduction of urinals for girls and women in school and public toilets in South Africa. Though the concept is relatively new and unknown, it is clear that there are existing problems which female urinals can effectively solve. Poor situations in school and public toilets do not keep girls and women from using them, and thus improved options are likely to be used. Field trials with a wall-mounted urinal demonstrated that as long as urinals are kept clean; adequate education is provided; and privacy is provided, adoption and acceptance of the technology in schools is likely.

R342 000
2017-2018

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Competitive, small-scale, solar desalination

University of Pretoria (Chemical Engineering)

2727

Findings from a previous WRC-funded study indicated that concentrated solar energy and phase change–based energy storage were not cost-effective options for small-scale desalination. Nonetheless the study did provide crucial insights into the key cost drivers for solar thermal systems. This study is a follow-up on this project and is aimed at design and testing of a low-cost, small-scale solar desalination unit which is robust and requires minimal maintenance or supervision. The study will investigate three possibilities for affordable small-scale desalination, all subject to the cost target set earlier of 0.08ZAR/L. As a baseline, a single-stage, batch flash system functioning at a reduced pressure below atmospheric will be designed and evaluated. This has two goals, firstly to determine the maximum temperature and pressure achievable by heating a batch of water in a low-cost vessel using only sunlight. Secondly to see if the 11.8 L/day target can be achieved by limiting the system heat losses and maximizing the amount of solar energy utilized by the system without using any heat recovery (at any rate technically infeasible for this approach). The second design to be tested aims to achieve the same target of 11.8 L/day but using a continuous-flow, single-stage, flash system at the lowest possible cost, i.e., no heat exchangers for energy recovery. The configuration will still be a single batch that is loaded once per day but circulates within the system throughout the day. The third and final system will aim to maximise energy recovery from both the liquid and vapour streams leaving the flash drum. This will enable clear economic evaluation of this system to conclude whether the added complexity increases throughput by a margin high enough to justify the extra costs. This investigation will enable clear and unambiguous comparison of the systems to prior designs found in literature and to each other, with the ultimate objective of selecting the most economical option for commercialization following this project.

R500 000
2017-2020

Superhydrophobic surface modification of polymer membranes for desalination by membrane distillation

University of Johannesburg; University of Zululand

2729

Polysulfones (PSf) and polyethersulfone (PES), are widely employed commercial membrane materials for the production of ultrafiltation and reverse osmosis membranes. PSf and PES can also be considered for membrane distillation as an alternative to PVDF because polysulfones are cost-effective, exhibit good chemical stability, mechanical strength, high internal porosity and ease of fabrication by phase inversion methods. The main disadvantage of using polysulfones for membrane distillation is their relative hydrophilicity compared to PVDF. Superhydrophobicity can contribute to a great extent in water treatment via membrane distillation (MD), which is an emerging membrane separation technology in desalination of seawater and brackish water, and wastewater. Therefore, this study investigates

the development and testing of novel polysulfone (PS) and polyether sulfone (PES) superhydrophobic nanocomposite membranes for drinking water treatment. The nanocomposites will be prepared by blending the polymer with nanomaterials such as metal oxide, graphene and CNT, which provide greater mechanical strength and roughness. The superhydrophobicity will be introduced on the membrane surface either by modification with low surface energy materials or plasma treatment. The nanocomposite membranes will be applied for desalination of groundwater, brackish water and seawater by membrane distillation.

R900 000
2017-2020

Programme 2: Water treatment for rural communities

Nanostructured materials for removal of inorganic pollutants from drinking water and subsequent use of metal-laden nanomaterials for antimicrobial activity, catalysis, sensor applications

University of Johannesburg; CSIR; Unisa (Florida); CSIR; Tshwane University of Technology

2732

The proposed project is aimed at investigating the removal of pollutants, such as heavy metal ions, from wastewater sources using modified-polymer nanocomposite membranes. The efficacy of the metal-laden nanocomposites as antimicrobial agents and further removal of anions from drinking water will also be tested. In addition to antimicrobial agents, the nanocomposites will be used as catalysts for organic transformation and in sensor applications. This would mean less waste generation and less chemical consumption thus reducing overall costs for water remediation. The polymer-based nanocomposites will also be made to be magnetic for separation purposes. Cytotoxicity studies will be carried through in order to ensure the safety of the treated water.

R900 000
2017-2020

Programme 3: Drinking water quality

Utilisation of open source software to find the hidden relationships in datasets and how this can be used to manage drinking water quality

CSV Water Consulting Engineers; Umgeni Water

2730

The approach (methodology and practice) to data analysis has changed dramatically in recent years with the emergence of data science and associated tools for data analysis. This project focuses on the use of R Open Source Software (and its associated Packages and GUIs) for the analysis and visualisation of routine water quality data. The project seeks to provide answers to these questions:

- What is the statistical relevance of rare microbiological or chemical exceedances and associated water quality data (free and total chlorine, pH, turbidity, sample temperature) in treated water samples?
- What can appropriate statistical analysis techniques tell us about the relationships between out-of-range

microbiological data (total coliforms, heterotrophic plate count, *E. coli* and other measurable variables?

Based on the findings, a decision support tool to assist with the verification and visualisation of water quality data based on R will be developed.

R600 000
2017-2019

The status and extent of de facto water reuse in South Africa
Chris Swartz Water Utilisation Engineers; University of the Western Cape; Unisa (Florida)
2731

The quality of drinking water sources is rapidly deteriorating on a global scale, largely due to overloaded wastewater treatment systems, industrial discharge and unsewered informal settlements. The situation is exacerbated during times of drought, when a large portion of river flow consists of wastewater (when the base flow is low). The drinking water treatment plants that were originally provided for drinking water production were not designed to treat poor quality water, and consisted of conventional water treatment processes. These plants are now considered to be de facto reuse plants, because they in fact reuse wastewater that is discharged to rivers and dams and then abstracted downstream for potable use. As a result of, in particular, the health implications of the rapidly growing occurrence of de facto reuse, this study is aimed at assessing the status and extent of de facto reuse in South Africa. Such a study would help water resource planners and public health agencies understand the extent and importance of de facto water reuse. The study will also allow the assessment of how available treatment technologies compare in terms of treatment performance (e.g., nutrient control, contaminant control, pathogen removal), and what the limitations and challenges of current technologies are.

R1 000 000
2017-2020

Programme 4: Water distribution and distribution systems

The impact of lowering water pressure on domestic water demand
WRP Consulting Engineers (Pty) Ltd
2722

The aim of this study is to provide a practical document that can be used by municipalities to determine how domestic consumption will be impacted if the water pressure is lowered at pressure reducing valves.

R340 000
2017-2019

Responsive pipe networks
University of Pretoria
2726

Aims:

- Understand temperature changes around a leaking pipe
- Understand strains in pipes undergoing ground movement

- Assessing the severity of a leak from rate of change in the measured temperature and strains
- Assess whether simultaneous monitoring of temperature below and strain in a pipeline enables leaks to be detected

R980 450
2017-2019

Production and application of biosurfactant compounds for the prevention and reduction of biofilms on various surface materials

Stellenbosch University; Cape Peninsula University of Technology; Namibia University of Science and Technology

2728

The quality of drinking water sources is rapidly deteriorating on a global scale, largely due to overloaded wastewater treatment systems, industrial discharge and unsewered informal settlements. The situation is exacerbated during times of drought, when a large portion of river flow consist of wastewater (when the base flow is low). The drinking treatment plants that were originally provided for drinking water production were not designed to treat poor quality water, and consisted of conventional water treatment processes. Aims: These plants are now considered to be de facto reuse plants, because they in fact reuse wastewater that is discharged to rivers and dams and then abstracted downstream for potable use. As a result of, in particular, the health implications of the rapidly growing occurrence of de facto reuse, this study is aimed at assessing the status and extent of de facto reuse in South Africa. Such a study would help water resource planners and public health agencies understand the extent and importance of de facto water reuse. The study will also allow the assessment of how available treatment technologies compare in terms of treatment performance (e.g., nutrient control, contaminant control, pathogen removal), and what the limitations and challenges of current technologies are.

R700 000
2017-2020

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Micro-pollutants and endocrine-disrupting contaminants (EDCs) in wastewater treatment systems: approach towards effective water reclamation, new treatment technologies, and development of an adverse outcome pathway network for risk assessment

Stellenbosch University; University of Bath; Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB; Erwat

2733

This study focuses on determining levels of priority micro-pollutants to be included in the National Toxicity Monitoring Programme (NTMP) and for better chemical compliance at WWTWs in terms of the Green Drop

reports. Detection and modelling of micropollutants in environmental waters and wastewater will also assist with epidemiological studies showing the use trends of micro-pollutants in communities, as well as drug abuse. The detection of micropollutants will also influence decision-making to implement water quality guidelines for micropollutants of concern. The study will also evaluate the implementation of the AOP framework for better risk assessment. In addition to the evaluation of priority micropollutants, the study will evaluate the efficacy of two promising technologies – the Hybrid Activated Sludge (HYBACS) and carbon-based electrochemical oxidation technology (CabECO) process for the removal of micro-pollutants, and reclamation of water for reuse.

R1 000 000
2017-2020

A nature-inspired approach for producing bio-cements from urine

University of Cape Town; EAWAG: Swiss Federal Institute of Aquatic Science Technology; NuWater South Africa (Pty) Ltd

2734

Aims:

- Determine the ideal fertilizer and bio-cement process and 'recipe'
- Manufacture bio-cement from urine

R342 000
2017-2018

Turning municipal sludge beds into bio-power plants using sediment microbial fuel cells

University of Cape Town; NuWater South Africa (Pty) Ltd

2772

Aims:

- Design and construct a novel SMFC and PMFC for municipal sludge treatment
- Achieve a higher power density than 3 000 mW/m^2

R1 310 000
2017-2020

Energy-sensitive wastewater treatment using integrated anaerobic digestion and advanced oxidation process

Vaal University of Technology; Talbot and Talbot; NuWater South Africa (Pty) Ltd; University of Cape Town

2773

- To apply CFD modelling to determine the optimal reactor hydrodynamic conditions for photodegradation
- To model the kinetics of sludge production in the biological process
- To determine the performance of ozonation on TOC reduction and sludge solubilisation
- To determine intermediate compounds of the AOPs and predict reaction mechanism
- To determine biomethane potential of the solubilized sludge and evaluate the performance of the AOPs as post-treatment methods

- To design and evaluate the performance of an integrated AD and AOP system
- To conduct energy analysis and economic analyses as well as analysis of carbon dioxide emission reduction of the integrated process

R1 710 000
2017-2020

The use of non-thermal plasma as a low-energy technology for wastewater treatment

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

2774

Aims:

- To design, construct, operate, and evaluate a low-energy demonstration unit for the treatment of municipal wastewater using plasma technology
- To treat several test samples of wastewater from different sources within the municipality of eThekwini with the aim being the removal of the most critical non-biodegradable pollutants and waterborne pathogens that are not effectively removed using conventional methods
- To evaluate the performance of the demonstration reactor unit based on the effectiveness in removing the non-biodegradable pollutants and the energy efficiency of the unit in comparison to various existing treatment plants and systems in literature
- To provide an advanced low-energy and sustainable technology against emerging pollutants as an option amongst various conventional wastewater treatment plants

R1 200 000
2017-2020

Design of the efficient plasmon-assisted semiconductor photocatalysts and their application in visible photocatalytic wastewater treatment

Cape Peninsula University of Technology; Unisa (Florida)

2775

The main aim of this proposal is to design an efficient plasmon-enhanced UV/visible light–responsive photocatalyst for solar photocatalysis water treatment. Plasmon nanoparticles have the desired optical properties, a large surface area, and their absorption can be tuned across the visible spectrum. Plasmon nanoparticles create an enhanced localized electric field and hence increase the photoinduced processes. To achieve the above stated aim the following objectives have been set:

- Synthesize novel metal oxide based photocatalysts in the presence of gold nanoparticles
- Characterize the synthesized composite photocatalysts using a range of techniques
- Investigate photocatalytic activities of the nanocatalysts for wastewater treatment under UV-visible light irradiation (i.e. degradation of organic compounds pollutants using immobilized photocatalyst)
- Investigate the reusability of the photocatalyst

R342 000
2017-2019

Application of emerging low-energy technologies for the removal of endocrine disrupting compounds in wastewater and wastewater sludge

TruSense Consulting Services; University of Pretoria (Chemical Engineering)

2776

Aims:

- Laboratory-scale investigations of PCS process for removal of EDCs from both wastewater and wastewater sludge
- Pilot-scale investigations of PCS process for removal of EDCs from both wastewater and wastewater sludge
- Optimization of the pilot plant operation/technology for efficient removal of EDCs
- Cost estimation of removal of EDC in the PCS process and comparison with existing processes
- Overall comparison of PCS technology with other technologies/EDC removal methods

R1 112 000
2017-2020

Integrating sustainable agricultural production in the design of low-cost sanitation technologies by using plant nutrients and wastewater recovered from human excreta–derived materials

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

2777

- Monitor the long-term effects of wastewater use for irrigation on soils, crop production, storage and risks of microbial contamination at Newlands experimental site, Durban, and Frasers Informal Settlement, Tongaat
- Assess the safety of HEDMs with respect to (i) pathogen contamination during handling, food production and consumption, (ii) the levels of pharmaceutical residues they contain and (iii) the risk of adding pollutants to the environment (particularly the atmosphere, soils, surface and groundwater
- Generate information on the fertilizer value, impacts on using HEDMs on the atmosphere, soils, surface and groundwater and develop guidelines integrating sustainable agricultural production in the planning and design of low-cost sanitation technologies including decentralized wastewater treatment plants for peri-urban and rural areas

R1 710 000
2017-2020

Programme 2: Application of appropriate technologies and tools

Impact analysis of the use of risk-based tools in selected 23+ district municipalities

Water Group Holdings (Pty) Ltd

2799

Aims:

- To develop a framework or methodology to assess the impact of the pilot study intervention on knowledge and skills improvement, set within the context of using innovative risk-based tools
- To assess the pre- and post-situation in terms of the pilot study, and to quantify the impact of applying the risk tools, on knowledge, skills and the capacity to improve services, by the participating persons and municipalities
- To assess the feasibility of rolling out similar projects at other municipalities, and providing a framework for such a roll-out
- To capture and document the lessons learnt, their impact, the challenges and opportunities for future roll-out, based on the learning from the pilot study
- To develop a detailed report on the findings and recommendation, as well as an easy-read illustrative WINSA lesson, for use and dissemination in the water sector

R300 000
2018-2019

Programme 3: Stormwater and sewerage systems

Monitoring and evaluation of sustainable drainage systems (SuDS) in a South African context

Isidima Design and Development (Pty) Ltd; University of Cape Town; City of Cape Town Metropolitan Municipality; eThekwini Municipality; City of Tshwane Metropolitan Municipality; Department of Environmental Affairs; Amanzi Obom Consulting cc; Greenhouse Systems Development; University of the Witwatersrand; University of KwaZulu-Natal (Howard College)

2725

Aims:

- To review case studies of SuDS schemes implemented within three of the major Metros (namely: City of Cape Town, City of Tshwane, and eThekwini Municipality), to investigate the effectiveness and suitability of these designs for the specific context
- To establish an effective monitoring programme within three of the major Metros (namely: City of Cape Town, City of Tshwane, and eThekwini Municipality), to investigate the performance of existing SuDS systems within different climatic conditions
- To compare the hydraulic performance of SuDS with a natural catchment condition and establish the impact of current SuDS design practice on flood mitigation
- To develop a SuDS Monitoring and Evaluation Guideline

R741 000
2017-2019

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 2: Integrated management

Municipal institutional and funding arrangements for efficient water provision and its impacts on regional economic and industrial growth and employment

University of Johannesburg; University of Cape Town

2723

Aims:

- Overview and identification of key performance indicators
- Develop a comprehensive panel dataset covering at least 5 years of municipal water provision for the country's water service providers
- Track municipal performance over the past few years in the efficiency of water provision, using the stochastic frontier analysis, data envelopment analysis or free disposable hull methods
- Assess the factors that impact on the efficiency of water provision, particularly on the efficiency gains of institutional arrangements (outsourcing or using public-private partnerships for water provision) and funding
- Development of benchmarking Excel-based tool on how to conduct a self-assessment
- Quantify the direct impacts of efficiency of water provision (through municipal operating and capital expenditure) on local economic growth

R1 368 000
2017-2020

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

Membrane performance characteristics considerations towards the implementation of membrane distillation crystallisation as a viable treatment technology for the treatment of hypersaline mining and industrial wastewater

NuWater South Africa (Pty) Ltd; University of Cape Town

2763

Aims:

- Determine the ideal membrane characteristics for the treatment of mine wastewater using MDC (focusing on membrane flux and fouling/scaling potential)
- Establish membrane selection criteria for different mining and industrial wastewaters in South Africa for use by industrial practitioners
- Determine the effects of mixing speed and impeller properties on crystal formation
- Determine ideal operating conditions (based on WRC Project K5/2223/3 results and the results from Aims 1, 2 and 3) to run the system as a continuous process

R1 836 400
2017-2020

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

Removal of dyes and toxic chemical species from industrial effluents using cryptocrystalline magnesite-bentonite clay composite

CSIR; University of Venda

2756

Aims:

- Conduct a detailed literature review on dye and toxic chemical species removal from industrial effluents
- To evaluate the physicochemical and mineralogical properties of magnesite and selected clays that deliver the most suitable properties for adsorption processes
- To synthesize, modify and characterise the adsorbent composites as alternative adsorbents
- To evaluate the optimum conditions for removing the selected dyes from wastewater by magnesite, magnesite tailings, selected clays and their composites using batch experiments
- To evaluate the optimum conditions for removing the selected dyes and toxic chemical species from wastewater from Unilever by magnesite, magnesite tailings, selected clays and their composites using column experiments
- To substantiate the experimental data and point out adsorption mechanisms using adsorption isotherms and kinetic models
- To characterize the field dyes and explore the treatment efficiencies of the synthesized materials using authentic dye effluents from Unilever at optimized conditions
- To assess the techno-economic feasibility of the used adsorbents as an on-site feedstock for dye wastewater and toxic chemical species treatment

R1 285 920
2017-2020

The reformation of organic rich wastewater into high-purity hydrogen

Stellenbosch University

2758

The repercussions of global climate change are increasingly a concern for policy makers as the consequences of these shifts are significant and wide ranging, and will particularly impact developing countries such as South Africa. There is therefore a strong drive, both internationally and in a South African context, to search for renewable sources of energy. In addition to this there has recently been an increasing focus on utilizing and valorising waste materials rather than simply landfilling or disposing of them. Industrial processes often produce wastewater streams with high organic loads, containing, for example, organic acids, phenolics and other carbon compounds which historically have proven very difficult to treat to within legislative requirements. Examples of such are waste vinasse from the sugarcane to ethanol process, or phenolic wastes from the chemical industries In general, treatment methods for these waste streams have involved simply reducing the organic loading, nitrogen

and phosphate concentrations to acceptable levels for emission, but no further value is derived from them. This project aims to bring these two concepts together, by developing a technology which consumes the organic portion of waste-waters to produce both high-purity hydrogen and purified water.

R1 649 000
2017-2020

The pulp and paper wastewater biorefinery: potential for concomitant value recovery and wastewater treatment

University of Cape Town; SAPPI

2760

Building on the review of waste resources in South Africa conducted in WRC K5/2380 and the recent NatSurv report, we aim to conduct a detailed mapping of the wastewater resource from the pulp and paper industry and its potential for value addition. This will include the volume, concentration and complexity, hence the amount of each of the important resources (organic carbon, N, P, water, other) contained within the effluent streams, the regional proximity of the resources, the suitability of these streams as feedstocks to the WWBR and their associated challenges. The integrity of these data will be interrogated and used to assess the value proposition of the pulp and paper WWBR.
We aim to identify products of interest for generation in the WWBR. These are expected to include commodity products of relevance to the pulp and paper industry, bio-based commodity products with potential value (economic, social or environmental), energy products and water fit for purpose.

Using two case studies, we aim to explore appropriate process flowsheets for WWBRs for these sites. Further, we aim to use the case studies to identify critical components of the WWBR and the influence of site complexity on the WWBR proposed. It is intended that the case studies will be selected from a large industrial player and a smaller industrial player.

From the most promising WWBR process flowsheets, we aim to identify key areas for new knowledge generation. In particular, we will identify critical technical knowledge requirements constraining the implementation of the WWBR in the pulp and paper industry. Areas where we expect new knowledge generation to be required include handling recalcitrant effluents, developing system resilience in response to variability in effluent flows, interactions between unit operations in the WWBR, and defined benefit to site, company and community.

We aim to address and resolve two to three of these technical constraints through focused research.

We aim to assess the WWBR process flowsheets with the highest potential through use of techno-economic analysis. This approach will identify value to the sites of the case studies as well as being used more broadly to estimate potential value – social, environmental and economic – of the WWBR approach to the sector.

R2 478 000
2017-2021

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Preventing acid rock drainage (ARD) generation from coal interburden waste rock – comparing long-term efficacy and techno-economic considerations

University of Cape Town; Anglo American Thermal Coal

2761

As the sixth largest global producer of coal, South Africa's economy is firmly supported by this revenue-generating mineral. With a production of approximately 260 million tonnes in 2014, coal provides in excess of 77% of the country's energy needs. The reliance on coal, together with increasing population and quality of life, results in a substantial accumulation of coal waste discards and fines. This poses a serious environmental risk as the sulphide minerals present in these discards may oxidise to form the toxic, highly saline and potentially highly acidic run-off referred to as acid rock drainage (ARD). With a predicted annual increase of approximately 60 million tonnes, it has become increasingly important to manage these waste materials and their disposal to alleviate this potential environmental burden. The aims of this project are:

- To utilise a combination of the static tests, biokinetic test, SCE and humidity cell columns to assess the ARD potential of coal waste rock, prior to and post treatment. This will allow both an understanding of the treatment of ARD prevention in the immediate and mid-term scenarios as well as improved understanding of the value of each of the tests for characterisation of the treated waste rock, leading to an appropriate suite of tests
- To demonstrate the upscale of the two-stage separation using flotation, described by Kazadi Mbamba et al. (2011, 2012) at pilot scale to yield additional coal value, sulphide rich tailings and sulphide lean tailings from coal fines or discards
- To evaluate the potential for ARD formation from coal waste rock through its simulated leaching
- To demonstrate at small crib scale the effectiveness of blinding of the coal waste rock dump with desulphurised tailings through packing the small crib using either blending or layers, building on the studies of WRC K5/2231
- To consider the alternative of accelerated leaching of the coal waste rock to establish the timescale required for its desulphurisation by reaction, as a function of particle size
- To establish potential approaches to handling the resultant sulphate- and metal-rich liquid stream, ideally with potential to reclaim products of value such a gypsum or ferric sulphate
- To evaluate these approaches to waste rock handling through techno-economic analysis of waste rock handling through 'as is' handling with ARD remediation, implementation of co-disposal with acid neutralising desulphurised tailings, and accelerated desulphurisation of the coal interburden waste rock through accelerated leaching.

R4 089 592
2017-2021

Pilot-scale semi-passive treatment of ARD – evaluation of treatment products for downstream use

The Moss Group; University of the Witwatersrand

2762

The management and remediation of mining impacted waters represents one of South Africa's most significant environmental challenges. Little attention has been paid to ARD from diffuse sources, such as waste rock dumps, coal discard heaps and tailings impoundments. These sources of ARD typically produce lower volumes and may be less aggressive, although heavily impacted discharges do exist. In addition, these ARD discharges may occur farther from urban centres and may be on land where access is no longer controlled, so could directly impact surrounding communities. In many cases, conventional physical or chemical remediation options may not be feasible, due to capital and operational cost, the need for highly qualified operators or the relatively low volume requiring treatment. Passive and semi-passive systems do not typically treat water to potable quality and the treated water is discharged into the receiving water bodies, where it is typically diluted further. In South Africa, further dilution of contaminants (sulphate salinity and toxic metals) is often not viable and if the treated mine water is to be used directly for agriculture or abstraction by local communities a more detailed study of the water quality is required. Additional important questions relating to the quality of the treated water, its applicability for agricultural use, the possible requirement for polishing and the potential application of the sulphur product as a fertiliser supplement remain. This project hopes to address these questions.

Furthermore, in order to demonstrate the effectiveness of semi-passive technologies to an often sceptical industry it is important that such a plant can be operated continuously for a longer period of time.

R909 378
2017-2020

Water conservation and water demand management in the South African mining industry: A compendium of best practices and case studies

Golder Associates Africa (Pty) Ltd

2764

The objective is to develop a compendium of best practice (national) in the water efficient design and operation of water and wastewater aspects of mining and mineral refining. The output of the project will be a compendium of best practices and case studies for use as a guidance document that will be of value to sector members to guide them in improving their operations towards water efficiency. The scope of work will cover the principal activities of extraction and processing of mineral resources (mining, beneficiation, residue disposal, auxiliary/support services), and will focus on the identification of current best practice, tools and technologies. The study will evaluate both incremental improvements in water efficiency through optimisation of existing assets and operations, and substantial improvements in water efficiency from the adoption of new (but proven at full or demonstration scale) technologies. It should also highlight new processes, technologies, plant types and systems, which realise more substantial efficiencies with provisos that:

- Only technologies that are proven at full or demonstration scale are recommended
- Technologies at pilot scale development are noted for future investigation and implementation
- Areas where new technical development is required are also identified and highlighted

R1 026 000
2017-2019

Programme 3: Minimising waste production

Piloting a combined metallurgical slag/sugar cane bagasse process for treating AMD

University of the Witwatersrand; University of Colorado; UCL Company (Pty) Ltd; Anglo American Thermal Coal; Phoenix Slag Services of South Africa (Pty) Ltd

2757

A previous study on the use of basic oxygen furnace (BOF) slag and stainless steel slag (SS) determined that BOF slag has significant potential as a reagent for treating AMD when using it to treat an artificial AMD and could potentially be used to replace lime as a primary neutralising reagent. The BOF slag could effectively remove all iron from solution and removed sulphate to a final concentration of approximately 400 ppm from a starting concentration of 6 000 ppm (> 90% removal). However, the study had a few limitations: the study did not determine if any minerals/metals were leaching from the slag into the remediated AMD and also did not seek to determine any ways to polish the effluent below 400 ppm sulphate. In other research, sugarcane bagasse has been shown to serve as an excellent host media for sulphate-reducing bacteria (SRBs), which have the ability to treat raw, untreated AMD (pH~3) by converting sulphate to sulphide which can then form insoluble precipitates. Thus, using BOF slag and bagasse either together or in series could have significant advantages for purposes of improving water quality. Interestingly, the coal-based AMD challenges and sources of BOF slag and sugarcane bagasse are all located within south-eastern Mpumalanga and KwaZulu-Natal. This research has been (and continues to be) conducted at lab scale in the Laboratories of the Industrial and Mining Water Research Unit, at the University of the Witwatersrand, Johannesburg. The next step is to design and construct a pilot plant capable of treating 1 000L/day on site, to treat real AMD. This forms the basis of this project.

R966 577
2017-2019

Assessment of cover design, construction and aging on water percolation and oxygen ingress, acid mine drainage generation and seepage qualities for coal discard facilities for the Mpumalanga Highveld

Terrasim cc; Stellenbosch University; University of Pretoria; University of the Western Cape; Geostratum Groundwater and Geochemistry Consulting; NEKA Sustainability Solutions

2759

The generation of AMD is mainly a function of the geochemistry of the mine geology, the activity of

microorganisms, the amount of water percolation and the ingress of oxygen into pyrite-containing coal discard derived from beneficiation, and waste rock and backfilled spoil material. The proper design and construction of soil covers on rehabilitated coal discard facilities and backfilled pits plays a major role in minimising the amount of water percolation and ingress of oxygen into the mining wastes, which in turn inhibits geochemical processes driving AMD production and ultimately reduces the volume and quality of contaminated seepage that could reach the saturated groundwater zone. Although the importance of covers is recognised to limit AMD generation, seepage volumes and contaminant flux into the saturated groundwater zone for rehabilitated coal mines, the long-term performance of suitable and well-designed covers is undocumented and no systematic study has assessed how the hydraulic properties of cover materials and vegetation characteristics have changed in the long-term for the coalfields of South Africa. The focus of the present study is to assess the material hydraulic properties, vegetation characteristics and cover performance on water percolation and oxygen ingress into coal discard dumps, AMD generation and ultimately seepage qualities into the groundwater for a watershedding cover, a poorly constructed store-and-release cover and a well-constructed store-and-release cover based on infield obtained material hydraulic properties and vegetation characteristics for old (i.e. > 5–10 years) covers that have been exposed to climatic conditions and environmental processes for a considerable period.

R1 725 000
2017-2020

Programme 4: Mining in the 21st century

Investigation into developing an enabling operating environment for ash backfilling into disused mines

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

2787

Backfilling into disused mines using ash has the potential to minimise water ingress (and consequently the generation of neutral, saline or acid mine drainage). The impacted mine water in many cases is in close proximity to surface water sources, and becomes a threat for contamination and building integrity. Ash typically has high neutralisation capacity which has the potential to address the impacted mine water and potentially mitigate/minimise the risk of acid mine drainage. Furthermore, certain ash exhibits pozzolanic characteristics and can form cementitious material which has low permeability to limit the movements of ions, such as sulphates. Additional benefits of backfilling may include prevention of illegal mining activities, stabilisation of unstable landscapes, and decreased risk of spontaneous combustion. Finding a large-scale and beneficial use of ash has been difficult due to two reasons. Firstly, its classification as a 'waste' under the Regulations, Norms and Standards of the Waste Act that were published in 2013 and amended in 2014. Currently there is no well-defined technical evaluation or permitting process to follow. Secondly, the circumstances or conditions under which ash backfilling

is feasible and/or beneficial have not been defined sufficiently to enable any particular site to make an initial assessment regarding the value of a site-specific investigation into the technical or practical feasibility of backfilling. The value of this project will be in developing the technical and regulatory framework for using ash in the backfilling process. This includes, but is not limited to: the site evaluation, the information required for the impact assessment, the necessary risk evaluation and mitigation plan. The results from the study and the findings from similar practices will contribute in shaping the technical and regulatory landscape and guidelines to ensure due diligence and oversight during the process. This project aims to develop an outline of the technical and regulatory process for backfilling disused mines with ash, either as a thickened slurry or paste.

R1 425 000
2017-2019

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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. Building on the baseline of completed projects, the priority themes approved for research commencing in 2015/16 were as follows: Determining the water footprint of selected fibre and fuel crops; water use of strategic biofuel crops; water use of agro-forestry systems for food, forage and/or fuel production; evaluation of the water use and nutritional productivity of food crops in the diet of the rural poor; contribution of inland freshwater fisheries to rural livelihoods; up-scaling of rainwater harvesting and conservation (RWH&C) to croplands and rangelands for food production and renewable fuel generation; modelling of irrigation farming profitability with curtailment of authorised water use; management guidelines for control of salinization with precision farming; seamless near-forecasting of rainfall for effective agricultural water management; and non-point source (NPS) pollution management from field to catchment scale.

OBJECTIVES

The strategic objectives of KSA 4 are as follows:

- To increase the biological, technical and economic efficiency and productivity of water use
- To reduce poverty through water-based agricultural activities
- To increase profitability of water-based farming systems
- To ensure sustainable water resource use through protection, restoration and reclamation activities

THRUSTS AND PROGRAMMES

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

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Programme 1: **Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture**	**Scope:** Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.
Programme 2: **Fitness-for-use of water for crop production, livestock watering and aquaculture**	**Scope:** Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Programme 1: **Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations**	**Scope:** In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

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

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Programme 1: **Sustainable water-based agricultural activities in rural communities**	**Scope:** Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities.
Programme 2: **Integrated water management for profitable farming systems**	**Scope:** Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

THRUST 4: WATER RESOURCE PROTECTION, RESTORATION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

Programme 1: **Sustainable water resource use on irrigation schemes and within river catchments**	**Scope:** With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.
Programme 2: **Impact assessment and environmental management of agricultural production**	**Scope:** Agricultural decisions to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, have wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

RESEARCH PORTFOLIO FOR 2017/18

COMPLETED PROJECTS

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

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

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

University of Pretoria; CSIR

2273

This study highlights that detailed observation on volumes of water actually used by a particular crop greatly facilitate accurate water footprint calculations for products of that crop. These detailed field measurements provide the necessary data and information for improved on-farm water management planning and irrigation scheduling. The vegetable, deciduous and citrus fruit industries are significant contributors to the Gross Domestic Product (GDP) of South Africa, leading to income generation and job creation. However, in order to grow in a sustainable manner, and in parallel to numerous other competing water users, water requirements for industry need to be carefully considered, allocated and utilised in the most efficient ways. The importance of accurate observations of actual orchard water requirements is critical in this regard, not only at farm-scale, but also for local and regional water resource planning and allocation. The provision of transpiration (T) and Evapotranspiration (ET) data for fruit trees and orchards, that is as accurate as possible, will facilitate more efficient water use.

R2 750 000
2013-2017

Determining water use of indigenous grain and legume food crops

University of KwaZulu-Natal (Pietermaritzburg)

2274

The study assessed two intercropping scenarios, a sorghum–cowpea–bottle gourd and a maize landraces–bambara groundnut–dry bean intercrop. The focus was on cereal–legume intercrops that featured indigenous cereal and grain legumes. Intercropping sorghum with cowpea and bottle gourd or maize landraces with either dry bean or bambara groundnuts did not have a negative effect on growth and yield of both sorghum and maize landraces. Under limited water availability, intercropping resulted in more of a facilitative than competitive interaction. Under rainfed conditions, intercropping improved overall productivity of sorghum and maize landraces translating to improvements in water use (WU), land use efficiency (LER) and water

use efficienecy (WUE). Overall, intercropping resulted in improved soil water availability as the legumes acted as a live mulch hence minimising unproductive losses to soil evaporation. Thus, under rainfed conditions, intercropping cereals and legumes would be beneficial in terms of improving resource use efficiencies (land, water and solar radiation). Intercropping also offers long-term benefits in terms of sustainability through the legumes' ability to fix nitrogen. However, the benefits of nitrogen fixed by the legumes to the current or subsequent cereal crop require further investigation. A major aspect of the current study was to model the selected indigenous cereal and legume food crops for extrapolation to other rainfed ecologies in South Africa. Two models were selected for this purpose – AquaCrop and APSIM. The two crop models are uniquely different, with AquaCrop being a simple water-driven model while APSIM is a complex radiation-driven model. AquaCrop was therefore used to model sole crops while APSIM was applied for the intercrop for which it was most suited. For the sole crop, AquaCrop modelling focused primarily on sorghum since millets and bambara groundnut were previously modelled as part of WRC Project No. K5/1771//4. With respect to modelling sorghum, AquaCrop was able to simulate canopy cover, biomass accumulation, harvest index and yield relatively well for all sorghum genotypes and different environments. With respect to intercropping, the APSIM model was able to simulate the sorghum–cowpea intercrop system under different water regimes. The model gave reliable simulations of phenology, biomass, yield and crop water use for both sorghum and cowpea under the different water regimes. Following calibration and validation of the crop models, a secondary objective was to then apply the models for scenario analyses in order to develop best management practices. AquaCrop was applied for a range of agro-ecologies across KwaZulu-Natal to assist with generating best practice management recommendations for cultivar choice and planting date selection. Similarly, APSIM was also used to assess different management scenarios for selected areas in KwaZulu-Natal and to develop best management practices for improving water use efficiency under intercropping. Major recommendations that were developed included cultivar selection, selection of suitable planting dates, use of rainwater harvesting to increase water availability, use of mulches to minimise soil evaporation and increasing plant populations in favourable agro-ecologies. In terms of agricultural water management, deficit irrigation was recommended for areas that had access to water for supplementary irrigation. However, proper irrigation scheduling is a prerequisite to achieving improvements in yield and WUE. Lastly, the current project succeeded in quantifying water use of indigenous cereal and legume food crops under varying environments. While the extrapolation to other rainfed agro-ecologies was limited to KwaZulu-Natal, due to availability of reliable data, the framework developed can be applied for a range of environments given that soil and climate data are available. The study provides a strong case for the promotion of underutilised, indigenous and traditional cereal and legume grain crops, especially in semi-arid environments. Underutilised indigenous cereal and legume food crops have potential role to contribute to crop production under climate change and variability as well as to food and nutrition insecurity in semi-arid regions. However, a major limitation to their production relates to the low potential and attainable yields of these crops, in particular minor grain legumes. This requires targeted efforts at crop improvement to improve their yields. In the short to medium term, the use of best management practices that include intercropping, appropriate cultivar and planting date selection as well

as rainwater harvesting and conservation techniques have potential to improve current yields and improve water use efficiency under rainfed conditions.

R2 910 000
2013-2017

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

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

Stellenbosch University; Auburn University; University of the Western Cape; Department of Agriculture, Western Cape; Department of Agriculture, KwaZulu-Natal; Department of Agriculture, Limpopo

2276

This project is the last in a series of studies with the aim of investigating the interaction of floating net cage fish farming and irrigation farm dams on water quality. It proposed to consolidate the outputs and further the impact of existing sources for particular advancements at fish farmer level. Products developed were made available in the home language of fish farmers to improve ease of reading and use. The study concluded that knowledge exchange as encountered in the Western Cape, KwaZulu-Natal and Limpopo Provinces is motivated and driven by a number of factors involving service delivery through government extension services, accessibility and affordability of ICT, specifically in rural Limpopo, and eventually the cost-benefit of using available information or purchasing specialised equipment to incorporate technical knowledge. Although the scope of the study was limited to these provinces, keen interest was expressed by fish farmers in Mpumalanga and the Eastern Cape to participate in similar studies. Hence future work could engage these farmers to provide a more comprehensive overview.

R1 950 000
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; University of the Free State; ARC Institute for Soil, Climate & Water; Department of Water and Sanitation; NB Systems; CSIR; University of KwaZulu-Natal (Westville)

2399

The 1996 South African Water Quality Guidelines comprise one of the most widely-used tools in water quality management. However, they are now viewed as significantly out of date. A Phase 1 Department of Water Affairs and Forestry (now Department of Water and Sanitation) project was completed by a panel of experts in 2008. They 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. The general aim of this project was to develop a software-based DSS able to provide both generic and site-specific risk-based irrigation water quality guidelines for South Africa. The DSS assesses fitness for use and establishes water quality requirements for the effect irrigation water constituents have on soil quality,

crop yield and quality, as well as irrigation equipment. For each of these, a number of suitability indicators were identified, as indicated below. The criteria used to determine the fitness-for-use category of each suitability indicator and the relevant calculation procedures, are presented and elaborated upon.

Suitability indicators:

- Soil quality: root zone salinity; soil permeability; oxidisable carbon loading; trace element accumulation
- Crop yield and quality: root zone effects; leaf scorching when wetted; contribution to NPK removal; microbial contamination: qualitative crop damage by altrazine
- Irrigation equipment: corrosion or scaling of irrigation equipment; clogging of drippers

The DSS is a user friendly, self-contained system, incorporating databases, help files and supporting information. Designing and establishing the DSS was a major undertaking and, as far as could be ascertained, a world first. Further refinement and the need for additional features were identified during the course of the project. These recommendations for further research include enabling the use of time series of water constituent data for analysis.

R2 600 000
2014-2017

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

Programme 2: Integrated water management for profitable farming systems

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

University of the Free State; PICWAT; Bioresources Consulting; Dresden University of Technology

2279

The general objective of this research was to develop appropriate management approaches for reducing electricity cost, improving water use productivity and increasing profitability of irrigation farming for selected irrigation areas in South Africa. Ruraflex is more profitable than Landrate, irrespective of system size and irrigation system delivery capacity since all the irrigation systems included in the analyses resulted in higher net present values using Ruraflex, which is a direct result of lower electricity costs associated with Ruraflex. An important observation is also that the total annual fixed cost charge for Landrate is consistently higher than the annual fixed cost charge of Ruraflex, and that savings can be achieved through careful planning of electricity supply points' sizes and locations. Altering the maximum notified demand

should be carefully considered as penalties apply if the maximum notified demand is exceeded. The timing of irrigation is of utmost importance since it has a direct effect on electricity costs and crop yield. Profitability of Ruraflex is closely related to irrigation scheduling practices. Careful consideration of the irrigation system design and irrigation scheduling practices is necessary. However, the assumption made by various researchers and irrigation designers that all available off-peak hours will be used first before irrigation will take place in more expensive time-of-use timeslots is voided by the fact that the water budget and the status of the crop will determine irrigation timing and amounts. During peak irrigation demand periods, the value of the marginal product is much higher than the marginal factor cost of applying irrigation water; therefore it is profitable to irrigate during peak timeslots. Smaller delivery capacities proved to be the most profitable for all the system sizes and electricity tariff structures investigated, as higher flow rates increased the energy demand. This increase in kW demand had a greater impact on the energy cost than the decrease in irrigation hours resulting from high system capacities. The conclusion is that careful consideration of the economics is necessary since smaller delivery capacities require much more intensive management, because longer irrigation hours are needed in order to avoid a decrease in crop yield.

R1 950 000
2013-2017

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

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. This study investigated the occurrence and levels of 10 priority pharmaceutical residues in water samples collected from various livestock farm environments in the Western Cape, followed by a health risk assessment for humans and the environment. 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.

R890 000
2015–2017

Vulnerability, adaptation to and coping with drought: The case of commercial and subsistence rainfed farming in the Eastern Cape

University of the Free State

2280

The 2015/2016 drought created awareness of the critical effects of a prolonged drought and the risks of water and food shortages. Whereas the agricultural sector has suffered the most as a result of drought in the past, densely populated urban areas are expected to also suffer water shortages in future droughts if South Africa does not plan properly for the next drought. Drought classification and the application of drought indicators are essential elements in drought management and drought monitoring. Drought classification has usually been based on certain indicator thresholds and provided a framework for drought management. The drought classification, indicator selection and indicator thresholds discussed in this report were the result of research completed as part of this project as well as inputs from the National Drought Task Team expert sub-committee for drought indicator development.

Drought was categorized in five categories namely (i) D0 – dry, (ii) D1 – moderately dry, (iii) D2 – severe drought, (iv) D3 – extreme drought, and (v) D4 – exceptional drought. Indicators were classified as primary indicators, which are easy to monitor on a daily basis and secondary indicators, which focuses more on drought impacts. Primary indicators were categorized as meteorological indicators, agricultural indicators, which are remotely sensed, and hydrological indicators. Thresholds were proposed for all the indicators but the difference between different sectors such as communal farmers and commercial farmers were also highlighted. Ten primary indicators are proposed for South Africa as a result of this research. The National Drought Task Team of South Africa accepted the proposed indicators as a good start and the Department of Agriculture, Forestry and Fisheries (DAFF) and the National Disaster Management Centre (NDMC) should formalise the use of these indicators.

R2 950 000
2013-2017

Coping and adaptation strategies for agricultural water use during drought periods
Cape Peninsula University of Technology; Department of Agriculture, Forestry & Fisheries
2602

This review showed that South Africa is a dry country that is prone to droughts. A closer look at the provinces shows that they experience drought differently, according to climate. The country is currently experiencing a severe drought. However, the amount of information available at the time of this review did not reflect the severity of drought experiences by the South African agricultural sector; neither did it reflect the work done by the government to mitigate drought effects. The absence of DMPs by the provinces implied lack of preparedness by the government and confirmed the view that drought management remains reactive. Regardless of the fact that the South African Government understands and acknowledges its mandate to manage drought, little evidence was found that action is being taken to implement the drought management policy. Nevertheless, it is important to acknowledge that South Africa has been able to develop a sound drought management policy. The national government has also taken strides in providing drought relief to its people. However, the extent to which relief has been received and has addressed the needs of the rural poor and smallholder farmers is yet to be revealed. It can also be concluded that there is limited research on drought in general, and on its occurrence and management in South Africa. No monitoring and evaluation are being done on the implementation and effectiveness of programmes for drought management. Therefore, it is difficult to determine to what extent the NDMP has been implemented and is achieving its purpose. Both IKSs and EWSs are critical in addressing drought in SA, and should not be used in isolation. On the same note, the context and environment in which these are provided should be conducive. This means that a holistic approach should be taken into consideration when using these tools of drought mitigation, including the social context in which different farmers operate, particularly the resource-poor farmers.

R200 000
2016

CURRENT PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

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

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.

R2 750 000
2013–2018

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.

R3 000 000
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.

R3 000 000
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.

R4 000 000
2015–2020

Water use of avocado and macadamia orchards

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

2552

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

R5 160 000
2016–2021

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

R3 000 000
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

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.

R4 300 000
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.

R5 000 000
2015–2020

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

R2 408 000
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 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.

R4 000 000
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.

R2 600 000
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.

R4 000 000
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.

R4 000 000
2015–2020

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

R3 870 000
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

R3 000 000
2016–2020

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 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.

R1 950 000
2013–2018

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.

R5 133 040 (incl. leverage)
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.

R3 000 000
2015–2019

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

R1 990 000
2016–2019

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.

R4 160 000 (incl. leverage)
2015–2020

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

R2 000 000
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

R2 386 000
2016–2019

Programme 2: Impact assessment and environmental management of agricultural production

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.

R3 700 000 (incl. leverage)
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.

R2 000 000
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.

R4 500 000
2015–2019

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.

R4 000 000
2015–2019

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

R6 000 000
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

R4 000 000
2016–2022

NEW PROJECTS

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

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

Water footprint as a sustainability indicator for table and wine grape production
C Jarmain (independent researcher); Department of Agriculture, Land Reform and Development, Northern Cape; Stellenbosch University; University of Pretoria; eLeaf; WWF South Africa; University of the Free State; Distell; Department of Agriculture, Western Cape; Cape Orchard Company; VINPRO; South African Table Grape Industry (SATI); WINEMS; Winetech; DOLE; Dried Fruit Technical Services
2710

Aims:

- Review how water footprint (WF) methodologies can be applied to table and wine grape production
- Apply WF for selected and representative grape commodities and products and make recommendations for improvement
- Develop and demonstrate a procedure whereby WF assessment can be carried out utilizing spatial datasets and propose a set of guidelines that industries/organisations can follow for implementing WF assessment within their organizations/industries
- Promote the benefits of a WF assessment to industries
- Build capacity and competence in WF assessment in wine and table grape industries

R2 989 600
2017-2021

Water use of indigenous fruit tree crops
CSIR; University of Zululand; ARC
2720

The overall aim is to quantify water use by indigenous fruit tree crops, understand their response to environmental variables, and to make recommendations on species suited to specific areas for possible future growth and expansion of indigenous fruit crop production in South Africa:

- To synthesize and compile available local and international knowledge on IFT crops and to shortlist species with commercialization potential
- To quantify the seasonal and annual water use, fruit and tree growth patterns of IFTs under a range of bioclimatic conditions

- To establish how key physiological processes that determine tree growth and productivity respond to environmental variables for IFTs growing in their natural habitats
- To develop or adapt appropriate models of water use by indigenous fruit tree crops in order to extrapolate the research results to other regions where IFTs grow
- To estimate the water productivity of different indigenous fruit tree crops in a range of bioclimatic conditions

R3 000 000
2017-2022

Operationalizing the increase of water use efficiency and resilience in irrigation (OPERA)

Stellenbosch University

2788

Aims:

- To identify specific market-driven, farmer demands for producing alternative crops and to relate operational services that bring precision irrigation for such crops and production system into practice
- To identify operational means to anticipate climate variability and critical moments of water scarcity in practice
- To identify, through experience and literature, the most adequate combination of soil sensors, plant-based sensors, remote sensing, weather forecast and simulation models that allow the better consideration of rainfall, evapotranspiration and soil moisture in irrigation scheduling
- To identify ways for operationalizing the upscaling, at the territory-scale, information allowing a better management of water scarcity and drought through literature and the collective contributions of OPERA partners
- To integrate experience in operationalizing precision irrigation from various climatic zones in Europe and South Africa to identify the best applicable service models

R750 000
2017-2019

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

Measurement of water pollution, determining the sources and changes of microbial contamination and the impact on food safety, from farming to retail level, of fresh vegetables

University of Pretoria; Stellenbosch University

2706

The aim of this study is to measure water pollution, determining the sources of and changes in microbial contamination and impact on food safety, from farming to the retail level, for selected fresh vegetable supply chains:

- To select and motivate for fresh, minimally processed and fresh-cut ready-to-eat vegetable produce to be analysed at stages of packhousing, processing and retailing at selected formal and informal markets in the Tshwane and Cape Town Metros
- To measure microbial contamination of fresh, minimally processed, fresh-cut and/or ready-to-eat packaged vegetables in selected fresh produce supply chains, from the farming packhouse and processing stages up to selected formal retailers

- To measure microbial contamination of selected fresh vegetables at selected informal traders/retailers
- To determine the microbiological quality of fresh vegetable produce from the farming stage (excluding field irrigation), to the packhousing, processing and retailing stages at selected formal and informal food supply chains, in order to identify potential contamination points
- To determine the prevalence and to characterise potential human pathogenic bacteria in the selected fresh, minimally processed and ready-to-eat vegetables sold at the selected formal and informal retailers and food supply chains

R4 000 000
2017-2021

Evaluation of heavy metal and microbiological contamination, and assessment of the suitability of Sand River water for irrigation

University of Limpopo; Department of Agriculture, Forestry & Fisheries

2709

Aims:

- To determine the nutrient status of the Sand River
- To determine heavy metal concentration of Sand River water, soils, sediment, aquatic plants and fish; and also determine the microbiological quality of the Sand River water
- To determine the suitability of the Sand River water for irrigation of tomatoes and onions

R2 000 000
2017-2020

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

An evaluation of agroforestry farms in Limpopo Province, South Africa

ARC Roodeplaat Vegetable and Ornamental Plant Institute; University of Venda

2714

The general aim of the study is to evaluate current status of agroforestry farms in Limpopo Province, South Africa:

- To identify and describe the characteristics of selected agroforestry farms in Limpopo Province
- To determine the potential constraint of rainwater on the establishment and expansion of agroforestry
- To determine factors that enhance farmers participation in the agroforestry sector in Limpopo Province

R1 200 000
2017-2020

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

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

Improving smallholder farmer livelihoods through developing strategies to cope and adapt during drought periods in South Africa

Cape Peninsula University of Technology; University of Venda; IIASA; Breede-Gouritz Catchment Management Agency; Department of Agriculture, Limpopo; Department of Agriculture, Western Cape; Department of Agriculture, Forestry & Fisheries

2716

Aims:

- To assess smallholder farmer characteristics and livelihood strategies in rural Limpopo and Western Cape Provinces
- Explore coping and adaptation strategies for agricultural water use adopted by smallholder farmers during drought periods
- Develop and test options for smallholder farmer coping and adaptation during a drought in crop farming systems in Limpopo and Western Cape
- Develop and test options for water-conserving fodder production strategies for smallholder livestock production
- Develop a livelihoods-based package for response to drought for smallholder farmers in South Africa

R1 500 000
2017-2020

Developing a guideline for rainfed production of underutilised indigenous crops and estimating green water use of indigenous crops based on available models within selected bio-climatic regions of South Africa

University of KwaZulu-Natal (Pietermaritzburg); International Water Management Institute

2717

The aim of this study is to develop guidelines for rainfed production of underutilised indigenous crops and estimate water use of indigenous crops based on available models within selected bio-climatic regions of South Africa:

- To conduct a state-of-the-art literature review focusing on identifying available information on the production, agronomy and water use of underutilised crops in South Africa; the review will focus on identifying locally available and international models that have been applied for modelling yield, water use and water productivity of underutilised crops and that can be adopted for South African conditions
- To parameterise/calibrate and test/validate available crop models for selected underutilised crops under rainfed conditions in South Africa
- To use available crop models to identify and map bio-climatic regions suitable for the rainfed production of selected underutilised crops in South Africa
- To use available crop models and climate change data to map climate change impacts on yield, water use and water productivity of the selected underutilised crops for rainfed production under South African conditions

- To use available crop models to develop production guidelines for selected underutilised crops based on best management recommendations for maximising yield, water use and water productivity under South African conditions

R2 000 000
2017-2022

Exploring the evidence of water–energy–food nexus linkages to sustainable local livelihoods and wellbeing in South Africa

University of Cape Town; Centre for Water Resources Research (CWRR); University of Fort Hare

2718

Aims:

- To conduct a systematic review of the evidence on the water–energy–food (WEF) nexus at different scales, with a particular focus on how the nexus affects livelihoods at household and community level
- To use case studies in catchment areas that span rural and urban communities, to explore how the WEF nexus plays out 'on the ground' and mediates the livelihoods and wellbeing experienced by different actors at the local scale, but with reference to how they are embedded within river catchments and their associated governance systems for water, energy and food. This will be done by trialling a household resource modelling approach.
- To strengthen awareness of WEF nexus thinking for integrated development planning and natural resource management at different scales amongst decision-makers; and extract recommendations for policy as well as research in order to move into an era of informed decision-making
- To identify key knowledge gaps in the interplay between WEF nexus and development that will need to be answered by longer-term research projects
- To trial a process of involving and up-skilling local youth together with their communities, thus empowering them to better understand how the WEF nexus impacts on their wellbeing, financial outcomes and economic opportunities

R2 300 000
2017-2020

Water use efficiency and carbon sequestration potential of indigenous crops (sorghum, pearl millet)

University of KwaZulu-Natal (Pietermaritzburg); ARC Grain Crops; University of Pretoria; IRD, France; Stellenbosch University

2721

Aims:

- To evaluate water use efficiency and soil carbon sequestration potential of sorghum and pearl millet varieties in comparison with commercial maize and wheat
- To assess response of selected soil properties (water-soluble C, microbial biomass, respiration, N mineralization and water retention) to organic carbon contribution of indigenous (sorghum and pearl millet) and commercial (maize and wheat) crops
- To build capacity of post-graduate students and smallholder farming communities on water-use efficiency and soil C dynamics in the context of climate change
- To identify contribution of indigenous crop production to global carbon credits

R2 627 272
2017-2021

School-based vegetable gardens: A promising approach to enhance school's feeding schemes and well-being of children with community participation

ARC Roodeplaat Vegetable and Ornamental Plant Institute; Vaal University of Technology; University of Pretoria

2784

Aims:

- Establishment of two school gardens, at the Bula Dikgoro & Mahlasedi Masana Primary Schools in Mamelodi area, that provide vegetables for nutrition to children and adults in the community
- Infrastructure development required for crop production in the school garden
- Human capacity development through school engagement and onsite training to transfer skills to the communities
- Measure and optimize water use of selected vegetable crops in school gardens to improve nutritional water productivity of the crops
- Implement simple irrigation and nutrient management tools/technologies to school gardens to improve irrigation management of selected vegetable crops
- Improved efficiency in protection of soil and water resources by rainwater harvesting and reduced nutrient leaching

R800 000
2017-2020

Assessing the state-of-art of the water–energy–food nexus in South Africa

University of KwaZulu-Natal (Pietermaritzburg); Jones & Wagener Consulting Engineers (Pty) Ltd

2790

Aims:

- To conduct a review of available information and knowledge about the water–energy–food (WEF) nexus in South Africa
- To conduct a state-of-the-art literature review on past, present and ongoing work on the WEF nexus focusing on current status, potential, challenges and opportunities for intersectoral WEF nexus planning.

  The review will pay attention to both technical and policy issues
- To develop a programme/framework for linking the WEF nexus to the Sustainable Development Goals (SDGs), paying particular emphasis on SDG 2, 6 and 7

Specific objectives:

- Review of current knowledge on WEF nexus in South Africa, including the review of current water, energy, food polices and strategies at national level
- Identify policy and research gaps, and make recommendations for practical application of the water-energy-food nexus in bringing about policy alignment and coherence.
- Develop a draft framework for implementing the water-energy-food nexus, linked to the SDGs, for the WRC and South Africa

- Develop mechanisms for identifying local research champions for the WEF nexus and development of a database of professionals working on the WEF nexus
- To develop a national guideline and research agenda for prioritising WEF nexus research, development and innovation for South Africa; the agenda should align with international initiatives to allow South Africa to tap into global funding for WEF nexus
- To a limited extent, propose indices and/or metrics as well as models that could be used to evaluate the WEF nexus

R300 000
2018

Programme 2: Integrated water management for profitable farming systems

Agricultural water management scenarios for South Africa.

University of the Free State; Department of Agriculture, Forestry & Fisheries; Department of Water and Sanitation; Agri SA

2711

The main aim of this research is to develop scenarios for agricultural water management in South Africa. These scenarios shall consider the social dynamics (including issues such as poverty, employment, demographic changes, security, etc), economic (including food production, industry, mining, global markets and trends, etc), ecological (including land degradation, climate change and variability, etc), political (including political stability and policy):

- To identify social, ecological and economic indicators in order to measure different scenario outcomes. These indicators will be sub-categorised in eight capitals namely, human, social, cultural, political, institutional, economical, ecological and infrastructure
- To determine the current status of agricultural water management in South Africa
- To review and provide critical analysis of current social, political, economic and ecological scenarios
- To recommend policy and action plans for sustainable agricultural water management based on four main scenarios
- To develop the framework for a dynamic decision support tool based on real-time indicator values and changes

R2 968 000
2017-2021

An investigation and communication strategy to support the uptake of available WRC research-based knowledge by irrigation schemes and commercial irrigated agriculture

Bunker Hills Investment; Isowat Consulting cc

2712

Aims:

- To enable the WRC to understand the factors that shape the use of research-based knowledge in commercial irrigated agriculture

- To give the WRC insight into the uptake and impact of its research products in commercial irrigated agriculture
- To identify success stories and map opportunities
- To develop a communication strategy, based on the outcomes of Aims 1–3, to improve awareness, acceptability and application of water metering by irrigation schemes and in commercial irrigated agriculture

R600 000
2017-2019

'Amanzi [Water] for Food': Developing a social learning network approach to knowledge dissemination and uptake in the agricultural learning system, focusing on the management, use and conservation of water for small-scale farming and household food production

Rhodes University; Department of Agriculture and Rural Development, Northern Cape; Unisa; Mahlathini Development Foundation; University of Mpumalanga; Fort Cox College of Agriculture and Forestry; University of Fort Hare; Department of Environment Affairs; Department of Agriculture Conservation and the Environment, North West

2713

Aims:

- To activate and facilitate use of agricultural water management knowledge associated with four key agricultural water management and use practices contained in WRC materials for small-scale food production through networked expansive learning approaches in the agricultural learning system involving multi-actors in the agricultural learning system (ATIs, NGOs, farmers, youth, LED officers and other relevant actors)
- To establish and expand multi-actor networks linked to agricultural training institutes (ATIs) for knowledge exchange, uptake and use and learning pathway development for youth
- To facilitate curriculum innovation in colleges of agriculture and universities using a training of trainers approach in an expansive learning network context which supports college lecturers to use content and processes in the WRC materials in their curricula
- To facilitate learning support innovations and productive demonstration site development in colleges and universities (ATIs), amongst NGOs, farmers, extension services and LED officers using a training of trainers approach in an expansive learning networks context which supports collaborative development of productive demonstration sites that can be used for training and in-situ learning, while also contributing to food production outcomes
- To facilitate wider mediation and sharing of agricultural water management and use knowledge via extended media platforms associated with the learning networks established and with national e-learning platforms such as the Agrisuite Online platform
- To evaluate and identify value created by a social learning network model for knowledge dissemination and use in the agricultural water sector with emphasis on value created for multi-actors in the

learning networks, but especially for women farmers and youth participating in small-scale and household agricultural food production systems

R2 929 600
2017-2021

Water use in food value chains of indigenous crops with special focus on production and post-harvest handling of food products

Monash University South Africa; Cape Peninsula University of Technology

2715

Aims:

- To review water use in the production, utilisation and post-harvest handling processes of indigenous crops in specific provinces of South Africa, with particular attention to legumes, tubers and leaf vegetables
- To analyse water utilisation along the value chains for selected indigenous crops, with respect to quantity and quality of water
- To apply the value chain analysis framework to understand the current practices for production, post-harvest handling, marketing and consumption of selected indigenous crops
- To develop an action plan that can enhance uptake, commercialisation and utilisation of indigenous crops in South Africa

R3 000 000
2017-2022

Collaborative knowledge creation and mediation strategies for the dissemination of water and soil conservation practices and climate-smart agriculture in smallholder farming systems

Mahlathini Development Foundation; Institute of Natural Resources NPC; Rural Integrated Engineering (Pty) Ltd; Rhodes University

2719

Aims:

- To evaluate and identify best practice options for CSA and Soil and Water Conservation (SWC) in smallholder farming systems, in two bioclimatic regions in South Africa. (Output 1)
- To amplify collaborative knowledge creation of CSA practices with smallholder farmers in South Africa (Output 2)
- To test and adapt existing CSA decision support systems (DSS) for the South African smallholder context (Outputs 2,3)
- To evaluate the impact of CSA interventions identified through the DSS by piloting interventions in smallholder farmer systems, considering water productivity, social acceptability and farm-scale resilience (Outputs 3, 4)
- Visual and proxy indicators appropriate for a payment-for-ecosystems based model are tested at community level for local assessment of progress and tested against field and laboratory analysis of soil physical and chemical properties, and water productivity (Output 5)

R2 700 000
2017-2021

Entrepreneurial development for establishing small farming businesses and employment by youth in rain-fed crop farming

University of KwaZulu-Natal (Pietermaritzburg); University of the Free State

2789

The aim of this study is to review and evaluate appropriate entrepreneurial development paths for establishing small-scale rain-fed crop farming businesses in the food value chain by the youth for improved rural livelihoods in at least two selected provinces of South Africa with rural unemployment:

- To evaluate natural, physical and financial assets (including market access) within a sustainable livelihoods framework for Southern Africa and giving specific attention to smallholder rain-fed farming potential in rural areas
- To evaluate human, social and psychological assets (including incentives of secure land tenure and leadership capabilities) in relation to entrepreneurial spirit and management requirements with particular attention to the youth in the selected rain-fed farming areas
- To evaluate currently available incentive schemes, access and effectiveness of the operation of these schemes for the youth
- To evaluate access to information such as market information and available advisory and support services such as extension and training
- To determine:
  - Reasons for interest/disinterest of youth in small-scale businesses in the rain-fed crop farming food value chains
  - Motivations for encouraging participation of youth in small-scale businesses in the rain-fed crop farming food value chains
  - Opportunities for small-scale businesses in the rain-fed crop farming food value chains.
- To determine aspirations and goals of youth to participate in rain-fed crop farming businesses and related food value chains
- To formulate and test appropriate development paths and farming models for establishing sustainable small-scale rain-fed crop farming businesses by the youth to increase food security, profitability, employment opportunities and livelihoods in rural areas

R3 000 000
2017-2022

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

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

Economic management of water and salt stress for irrigated agriculture: A precision agriculture case study

University of the Free State; Stellenbosch University

2708

The aim of this study is to develop and apply a bio-economic model to economically manage site-specific water and salt stress in irrigated agriculture:

- To develop and integrate an economic model with a transient-state salinity simulation model to evaluate the profitability of alternative salinity management guidelines for selected case studies

- To optimise the integrated bio-economic simulation model to determine optimal management strategies for selected case studies
- To develop economic guidelines for managing site-specific water and salt stress

R2 650 000
2017-2021

Programme 2: Impact assessment and environmental management of agricultural production

An integrated approach to managing and mitigating the risk of agricultural nonpoint-source pesticide pollution to the aquatic environment

Freshwater Research Centre; CSIR; ARC; University of Pretoria; Cape Nature

2707

Aims:

- Knowledge review of current management practices aimed at reducing pesticide impacts in the environment
- Identify priority areas for implementation of management practices through integrating recently developed pesticide use maps with geographical data to produce maps of aggregated risk to the environment
- Develop calibration guidelines for small-scale farmers designed to reduce pesticide application rates and associated environmental impacts
- Develop relative risk-based guidelines that enable farmers to identify the relative environmental risk of different pesticides registered for use on a crop
- Perform field- and catchment-scale modelling studies in two catchments under different cropping systems to evaluate the effectiveness of different management scenarios in reducing pesticide risks in the environment
- Perform field- and catchment-scale monitoring studies in two catchments under different cropping systems to validate model outputs and evaluate the effect of existing management practices on pesticide transport and risks in the environment

R4 000 000
2017-2022

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