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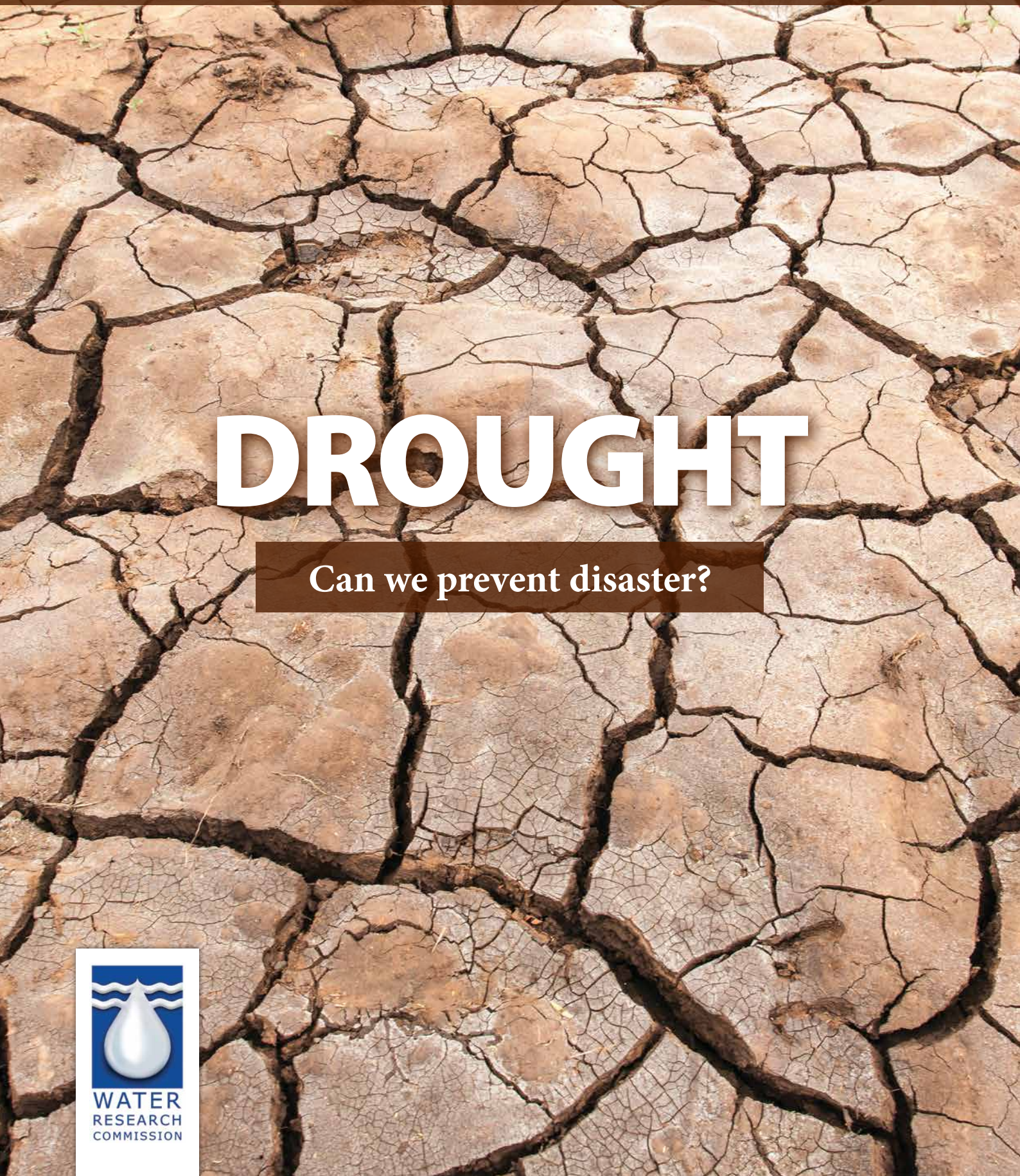

DROUGHT

Can we prevent disaster?

WATER RESEARCH COMMISSION

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WATER TECHNOLOGIES DEMONSTRATION PROGRAMME

A KEYSTONE FOR WATER TECHNOLOGY INNOVATION

VISION

To bridge the gap between water research and the market to achieve a connected water innovation system that delivers socio-economic benefits for South Africa.

The WAter Technologies DEmonstration ProgRamme (WADER) aims to bridge the gap between the R&D and commercialisation stages of the water innovation continuum by moving technologies out of the laboratories and proving them in real-world, test situations.

By coordinating the demonstration of water technologies in operational environments, WADER aims to increase the adoption of appropriate technologies and enhance the water innovation value chain. High-level demonstrations will serve to assess the technical, social, economic, regulatory and environmental attributes of the technologies. Each technology demonstrator will entail multi-player collaborations and a strong technology transfer component i.e. the transfer of skills, knowledge, methodologies, etc. to academia, government, business and civil society.

WADER WILL

• Collaborate • Coordinate demonstrations • Inform • Connect stakeholders • Assess and showcase technologies

WADER WILL NOT

• Provide funding • Endorse technologies • Accredit/certify technologies, individuals and/or organisations • Generate standards • Commercialise technologies

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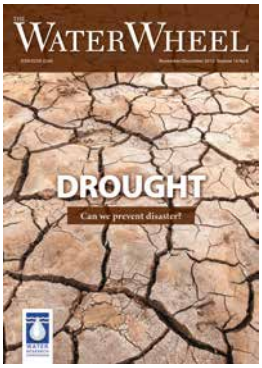


Cover: *A current Water Research Funded study is strengthening South Africa's knowledge armoury against large-scale drought events. Article on page 14. (Cover photograph by Peter Chadwick/Africa Media Online)*

WRC CEO, Dhesigen Naidoo

Fluid Thoughts

The year in focus - 2015

The year 2015 has been a vanguard year globally.

We have as the global community confronted some of the conventional wisdoms and dominant trends on the wake of the reality bites of some of the crispest challenges facing us in all of our time on Earth. The water year began with the World Economic Forum concluding in the Global Risk Register that water (the challenge of water security and the possibility of water crisis) constitutes, on a combination of likelihood and impact, the single highest risk factor to the global economy.

This convergence of the global community of both public and private sector players, unique in modern times, served as an important stimulus to another important coming together, now of global leaders, to develop an important international work-plan for the next 15 years. In September, heads of state and government met at the United Nations and agreed on the most ambitious set of targets we have seen in recent times – the Sustainable Development Goals or SDGs.

The SDGs build on the achievements of its predecessor, the Millennium Development Goals (MDGs), with a much higher level of ambition and resolve with the primary goals of the complete eradication of poverty and ushering of a world where the basic needs of all human beings are met in a sustainable manner. In many ways this reminds us of the local discussions we ourselves had converged on at a much smaller scale with the RDP or Reconstruction and Development Programme. Among the 17 SDGs is a stand-alone goal for water and sanitation – SDG6 – which has the target of achieving by 2030 the universal access to safe water and dignified sanitation for all human beings on Earth.

There are three different tensions that we have to align if these ambitions are to be achieved in our lifetime. On the positive side, we have never had such a dramatic global convergence on such an ambitious set of global targets for the poor and vulnerable before. At the same time, we have to be realistic and expect that the different global political tensions will indeed play themselves out in the implementation plan.

The second tension is that we have adopted this plan in the middle a difficult period of global economic contraction, one where the rapid and quick wins of the emerging markets have sobered in their maturing into the formidable challenge of stagnating demand in the developed world. In this domain, Africa remains an interesting positive outlier albeit from a lower baseline.

Unfortunately, because of the mature characteristics of its economy, South Africa falls a little outside this net. But the big question on the SDGs is of course the financial barriers to achieve implementation. There are many innovative financial models currently in discussion, ranging from cooperatives development to newer, easier models for raising debt capital and the emergence of new players in the Development Bank space like the BRICS Bank.

The third tension is the seemingly unstoppable juggernaut of increasing global inequality, both between nations as well as between individuals. Our challenge is to find within this tense, but highly fluid environment, the strings of innovative convergences that will eventually result in a more sustainable world. The test platform of Cop 21 of the United Nations Framework Convention on Climate Change (UNFCCC) is almost upon us in this regard. When the world's leaders addressed this matter in New York, this matter they embraced the ambition and recognised the challenges.

In the words of Narendra Modi, Prime Minister of India, "Just as our vision for Agenda 2030 is lofty, our goals are comprehensive." This is indeed true. The 17 SDGs are described in 169 targets and have to perform adequately to 834 indicators. Zimbabwean President, Robert Mugabe, offered a succinct summary of the moment when he said that the SDGs represents a "pathway to a brave new world", one that can only be achieved through "conscious construction" and calls for the creation of "a new global citizen".

Closer to home, we begin this journey in the midst of one of the most severe drought events in the democratic South Africa. We have declared disaster areas in three provinces to facilitate the release of resources for emergency interventions to safeguard affected people and where possible their livelihoods in the agricultural domain. In addition, the science indicates that this is due to the coming together of two natural phenomena. The first is that in the manner of wet dry cycles in South Africa, this dry spell is overdue by about five years. The current severity is however unprecedented.

The second is that the world is in year two of an El Niño cycle and one of the affected areas of this precipitation frameshift is

National and international water experts together contemplated South Africa's water future at the recent WRC Symposium.

of course Southern Africa. This may mean that we are in year two of a five to seven-year dry cycle. Add to this the vagaries of climate change with 2015 predicted to be the warmest year in recorded history globally.

These matters were deliberated at length in the September Water Research Commission Symposium and Water Technologies Summit. The primary conclusions were that while we already have many of the technological solutions at laboratory scale, we need to rapidly increase our investments in moving them to market ready products that can be use on the ground to increase our water security.

The second is that we need to empower the roll-out of the Water Research Development and Innovation Roadmap so in a decade from now we not only ensure basic water security, but organise that our water resources and water products become a key player in South Africa's economic growth and global competitiveness. To enable this we need to facilitate the development of large pools of skilled talent in the water sector and the development of a significant private sector component in the South Africa water Industry. Minister of Water and Sanitation, Nomvula Mokonyane, and Minister of Science and Technology, Naledi Pandor, have been explicit about government's commitment to this agenda. We need to rapidly expand that team with higher participation of the business sector and civil society.

South Africa has been a dry country in all of human recorded history, and our ability to thrive has always depended on our water ingenuity. From the Khoi San using ostrich eggs for water capture, storage and transport innovations in ancient times to becoming the world foremost nation in the field of water transfer technology and inter-basin plumbing we have enjoyed world leadership. This opportunity once again has come around, this time around smart water purification, supply diversification and heralding a sanitation revolution characterised by no and low water sanitation solutions. Water smart citizens – individual and corporate – are at the centre of this narrative. Team South Africa can and must lead in the water domain to ensure a successful Mzansi.

Diary

Young Water Professionals
November 16-18
The theme for the 4th YWP South African biennial conference, which will be held in Pretoria, is 'Stop talking, start doing'. Conference topics include domestic and municipal water and sanitation; drinking water and bulk water supply; industrial and mine-water; environment water; and capacity building and training. Enquiries: Jaco Seaman (Conference organiser),
Tel: +27 (0)11 805-3537; Email: events@wisa.org.za; Visit: www.ywp-za.org/

Water loss
February 1-3
The International Water Association (IWA) Water Loss conference will take place in India. Visit: http://www.waterloss2016.com/

Large dams
May 15-20
The 84th Annual Meeting of the International Committee of Large Dams will be held in Sandton, Gauteng. This is the first time since 1994 that this international conference is coming to South Africa. Visit: www.icold2016.org

Water
May 15-19
The Water Institution of South Africa is hosting its biennial conference at the ICC in Durban with the theme 'Water – the ultimate constraint'.
Enquiries: Jaco Seaman (Conference organiser), Tel: +27 (0)11 805-3537;
Email: events@wisa.org.za; Visit: http://www.wisa2016.org.za/

Wastewater technologies
June 13-16
The 13th IWA Leading Edge Conference on Water and Wastewater Technologies will take place in Spain with the theme, 'Evaluating impacts of innovation'. Visit: http://www.let2016.org/

Geology
August 27 to September 4
South Africa is hosting the 35th International Geological Congress in Cape Town. The event is aimed at, among others, contributing to the advancement of fundamental and applied research in the geological sciences and to provide a space where ideas and information can be exchanged across the geoscience disciplines. Visit: www.35igc.org

World water
October 9-13, 2016
The IWA World Water Congress will take place in Brisbane, Australia with the theme 'Shaping our water future'. Visit: http://www.iwa-network.org/event/world-water-congress-exhibition-2016/

WRC and SIWI initiate new community of practice on water pricing

The Water Research Commission (WRC) with the Stockholm International Water Institute (SIWI) has initiated a new community of practice on water pricing.

In a number of countries, water scarcity and water pollution are now being seen as threats to national development. This is of particular importance for national planning in countries that are experiencing rapid economic growth.

As a result, there is an increased interest from policy makers in water pricing as a solution to several of the main water challenges, but getting it right is often complex. This is due to the various pricing tools that are available, the multiple objectives they can be used for, as well as the variety of water uses for which they can be implemented.

Pricing of water also affects a range of well-entrenched traditions and beliefs, as well as vested interests. Also, given the fundamental public interest in water resources management, access to drinking water and water for economic development, pricing and regulatory instruments need to be used in combination.

For instance, the balance needs to be found between charging the full cost of water for industrial use (including pollution charges), and support given to emerging industries so that they become competitive. In agriculture, food security is often invoked to subsidise water for agriculture.

Subsidies may, however, benefit non-food crops, such as inputs to biofuel or inefficient irrigation practices. Water pricing might be an option to break the vicious circle of low-quality water services and management coupled with low-cost recovery and under-financing.

Not surprisingly, the debate is characterised by misinterpretation and confusion around concepts and objectives, which hinders progress towards better water management. The SIWI-WRC community of practice is aimed at addressing the need for a multi-disciplinary relook at how we can reflect scarcity in water prices, while at the same time recognising environmental and social values of water.

During World Water Week, which took place in Stockholm, Sweden, earlier this year, researchers and practitioners from various fields jointly mapped the complex area of water pricing and identified knowledge gaps in view of currently policy challenges as well as options to address them.

As an outcome, it was decided to initiate a community of practice which will increase the understanding across academic disciplines, through undertaking joint research, as well as identify relevant policy-making processes where there is interest to make use of the new knowledge available.

New freshwater field guide published

A new freshwater field guide is available from Struik Nature.

The publication, *Freshwater Life, A field guide to the plants and animals of southern Africa*, is the first comprehensive, illustrated field guide to aquatic life in the wider southern African region. The book was authored by Charles Griffith, an Emeritus Professor in the Department of Biological Sciences at the University of Cape Town (UCT); Jenny Day, an Emeritus Associate Professor in the same department; and Mike Picker, an Associate Professor in UCT's Department of Biological Sciences.

This ground-breaking book spans all aquatic life forms, from the large and conspicuous vertebrates, through insects, molluscs and other invertebrates, to aquatic plants and microscopic algae.

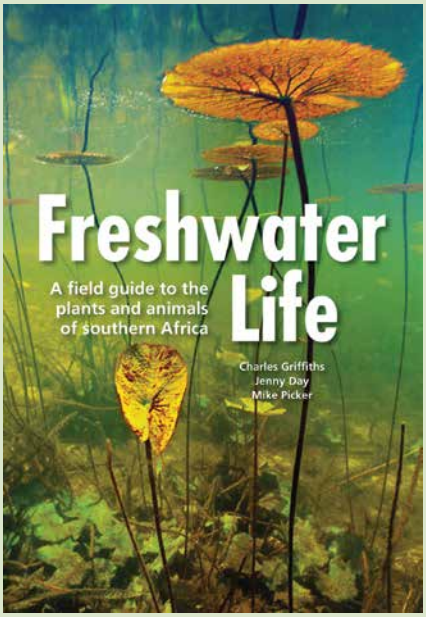
More than 1 000 freshwater organisms are included, species having been selected on the basis of how likely they are to be encountered. Descriptive text and notes on the ecology of each species are accompanied by photographs and distribution maps.

A comprehensive introduction details the ecology and significance of freshwater systems in southern Africa.

This indispensable, easy-to-use guide will prove invaluable to outdoor enthusiasts, students and conservationists.

The book is available in soft cover and with PVC jacket.

Visit www.randomstruik.co.za to order.



Damaged dam removed in Kruger National Park

The Kruger National Park (KNP), in conjunction with the South African National Defence Force (SANDF) demolished the dam wall at Sirheni, one of the bush camps in the northern part of the park.

The dam was damaged beyond repair during the 2013 floods. Explosives were used to demolish the dam wall, after which the remains were removed as part of the rehabilitation process.

The area around the target structure was cleared to ensure the safety of animals and humans.

This is the latest artificial watering point to be closed by the KNP in the last eight years. Artificial waterholes where water did not occur previously have led to numerous ecological problems such as erosion and other environmental degradation.

This also resulted in undesirable consequences for the rare herbivore species, such as roan and sable antelope, increasing grazing competition by the more abundant herbivores. Conservation management has taken steps to rectify these consequences by closing and demolishing certain artificial water points.

These will be replaced by naturally occurring waterholes in the area where possible and where ecological consequences are not likely.

"With continuous research data at our disposal, we have gradually changed our outlook on biodiversity management over the years. With this data available, policies and procedures can be revisited and revised; and that is evident in the change in policy regarding water distribution in the park," noted KNP General Manager: Communications and Marketing, William Mabasa.

SAEON launched Karoo shale gas ecology project

With the prospect of shale gas development looming across large parts of the country, the potential environmental costs are high on many people's minds, with all manner of environmental disaster being associated with 'fracking'.

Ultimately, the controversy around shale gas development stems from the extremely rapid growth of the industry, which has outpaced both research and legislation across the world. As a result, shale gas development impacts are not well known, with well-researched studies only starting to emerge now.

Our current poor understanding limits our ability to manage shale gas impacts effectively, or even predict what these are likely to be, and urgent research into the impacts of shale gas development on the Karoo is required. In South Africa we are fortunate to have an opportunity to establish a research and monitoring programme for shale gas impacts before development commences in order to address these needs.

With this in mind, SAEON has launched the Karoo Shale Gas Ecology Project out of the Arid Lands Node, with seed funding from the National Research Foundation (NRF). The timing of this has been ideal as the project has been able to link up with a number of other initiatives currently happening in the Karoo, including the Strategic Environmental Assessment (SEA) for Shale Gas Development.

SAEON's Karoo Shale Gas Ecology Project will be participating with the Council for Scientific and Industrial Research (CSIR) and the South African National Biodiversity Institute (SANBI) on the SEA, providing a variety of inputs for the process including training and vegetation mapping. The project will also be operating independently, developing a baseline of the Karoo environment, ecosystem structure, function and process with an eye to predicting sensitive receiving habitats and species likely to be most vulnerable to shale gas development impacts.

Ultimately the project aims to develop a long-term monitoring protocol for shale gas impacts that can be rolled out across the Karoo as the zones where wells will be developed become clear. SAEON anticipates that it will also be using conservation areas and protected environments such as the SKA to develop control and benchmarks sites.

Although the monitoring sites will be aimed at assessing shale gas development impacts, this will involve a lot of baseline data collection, which will help address the paucity of biological data collection prevalent across most of the Karoo, as well as address many other potential questions.

Source: SAEON

R600-m allocated towards raising of Hazelmere Dam wall

The Department of Water and Sanitation has allocated R600-million towards the raising of the Hazelmere Dam wall in KwaZulu-Natal.

The project entails augmentation of water supply to the KwaZulu-Natal North Coast by increasing the yield of the dam for medium-term supply. In this process the structure will also be stabilised.

By September this year R16-million had already been spent on the appointment of a civil works contractor as well as a demolition sub-contractor who have started work on site.

In the meantime, eThekwini Municipality announced that water levels in the dam remained low, standing at less than 30% in October.

New partnership aimed at fast-tracking research and innovation

The Water Research Commission (WRC) has signed a Memorandum of Agreement (MoA) with the USA's Water Environment Research Foundation (WERF) to enhance water technology innovation in South Africa.

The agreement follows the launch of the joint WRC-Department of Science and Technology (DST) Water Technologies Demonstration Programme (WADER) last year, aimed at promoting the early adoption of promising technologies and accelerating innovation in the water sector.

This programme is now expected to grow further as it collaborates with the WERF-funded Leaders Innovation Forum for Technology (LIFT), which is designed to move innovation into practice. It is expected that South Africa will gain from this partnership as LIFT accelerates water technology demand and adoption, and engages the entire water sector in all phases of the innovation process. This partnership will allow for an exchange of ideas on perspectives on the direction the industry is taking, and high-priority technology topics.

Signing the agreement was Dr Amit Pramanik, WERF Interim Managing Director and WRC CEO, Dhesigen Naidoo, while Dr Henry Roman of DST looked on.

Millions still food insecure in South Africa

Despite meeting the Millennium Development Goal Target of halving those that suffer from hunger, South Africa still has millions of households that are food insecure.

Up to 70% of households in South Africa's informal settlements skip meals or eat the same meal on most days. This is according to the Medical Research Council as reported in the *Conversation* newsletter.

According to the MRC, whose research was released ahead of World Food Day on 16 October, breadwinners also regularly struggle to provide meals or worry about having no food or money to buy food.

While the study was conducted on a small community in Johannesburg, this is a reality for people who live in informal settlements across the country, noted Nisha Naicker, Senior Specialist Scientist in the Environment and Health Research Unit of the MRC.

In adults, food insecurity is linked to detrimental health outcomes such as obesity, chronic diseases and mental health disorders. In children, there is a link between food insecurity, stunting, poor development and decreased academic ability.

There are many reasons for food insecurity in South Africa. These include poverty, lower levels of maternal education, unemployment, larger household size, and households that experience events that place an added demand on their budgets.

Another factor is the increasing trend of people eating more cheap, fast foods and less nutritious foods. People cope with food insecurity by decreasing the variety of foods they eat, limiting their portion sizes, and eating cheaper foods. Research shows this negatively affects their nutritional status.

The MRC has provided vegetable seeds to participants and local non-governmental organisations to plant fruit trees in one of the study sites. To fix the challenge of food insecurity in the short term, social grants may help to alleviate food insecurity to some extent as it will increase household income.

"But in the medium and long term, solutions such as increased employment opportunities, education and female empowerment is required to significantly lessen the burden of food insecurity," concludes the MRC.

Source: www.theconservation.com

New from the WRC

Report No. TT 632/15

Optimising fog water harvesting in South Africa (J Olivier, J van Heerden & H Rautenbach)

Fog harvesting for domestic consumption has been studied in South Africa for a number of years. The aim of this project was to optimise fog water collection. The project had three objectives, namely to understand the physical and chemical complexities of fog and its formation, to optimise the fog harvesting process and to develop novel products that could improve on existing fog water measuring devices as well as optimise the fog net design in terms of structural stability and fog water yield.

Report No. 2164/1/15

Developing methods for converting digitised rivers into a hydrological drainage network (HL Weepener; JJ le Roux, EC van den Berg; DR Tswai & JP Nell)

In this study techniques were investigated to create a South African river network that is repeatable and applicable to all the water catchments in South Africa. The methodology was implemented on two selected catchments and aimed to produce a network that will contain rivers similar to the 1:250 000 scale topographic maps at an accuracy that is equivalent to the 1:50 000 scale.

Report No. 2067/1/15

Predictability and attribution of the South African seasonal climate (K Lawal; P Wolski; C Lennard; M Tadross; B Abiodun; O Angélil, RC Mota & D Stone)

This project, which ran from 2010 to 2014, had two main goals concerning South African seasonal climate: to characterise the degree to which the predictability of seasonal forecasts varies from year to year, and to identify causes of such variations; and to characterise the degree to which anthropogenic greenhouse gas emissions have altered the chance of extreme months. In addition, the project included a case study extending the predictability and attribution methods to a hydrological case study: the streamflow discharge into the Okavango Delta, Botswana.

Report No. 2187/1/15

Desktop provisional ecoclassification of the temperate estuaries of South Africa (L van Niekerk; S Taljaard; JB Adams; D Fundisi; P Huizinga; SJ Lamberth; S Mallory; GC Snow; JK Turpie; AK Whitfield; TH Wooldridge)

The main aim of this project was to develop a desktop method for the Provisional EcoClassification method for estuaries that provided for a comparative, regional scale assessment. The Provisional EcoClassification included the present ecological status, the ecological importance and protection status, a provisional recommended ecological category (REC) as well as mitigation measures towards achieving the provisional REC.

Report No. 2188/1/15

Status of Nile crocodile in north-eastern KwaZulu-Natal and conservation management recommendations (CT Downs; P Calverley; G Champion; X Combrink; J Myburgh; M Summers; J Warner)

The Nile crocodiles in KwaZulu-Natal are an important component of the South African population, but the effects of the current threats on the separate populations need investigation. One of the study areas in this investigation, the Lake St Lucia estuarine system, contains the largest Nile crocodile population in a single waterbody in South Africa. This study was aimed at investigating the Nile crocodile's spatial and reproductive ecology, population status, and health in Lake St Lucia, Ndumo Game Reserve and Pongolapoort Dam to make management recommendations.

Report No. TT 627/15

Understanding sewage pump stations – Development of a SEWPUMP Tool (HE Jacobs, ML Griffioen; C Loubser & J Tulleken)

Pumps are essential components in most sewer systems and are often considered by operators and managers to be the most problematic. This project set out to address a number of pertinent issues with regards to sewage pumps, pump stations, and related elements of sewer systems. Key objectives of this study were to conduct a knowledge review of sewage and pumps; select or derive a classification system for sewerage pumps and related problems; conduct field work and data collection to determine the types of problems typically experienced during the operation of sewerage pumps and the possible causes and to better understand these problems; and analyse the field data in order to extract useful information; and develop a practical software tool intended as a training and communication tool regarding pump station problems.

Report No. 2222/1/15

Framework for the management of wetlands within catchments where Eskom operates (A Venter & S Mitchell)

The wetland management framework (WMF) developed through this project is aimed at providing guidance to Eskom in the decision-making and management of wetlands on wetlands on Eskom property although it is suitable for broader application. The intention of this document is that it should provide an industry standard that will get embedded in Eskom's modus operandi and be used by Eskom personnel. To this end the structure has followed that of the Eskom Project Life Cycle Model (PLCM). This project has added an extra dimension to the Eskom PLCM by creating a process for the management of wetlands within the current legal environment and the current understanding of the ecosystem services in a format that may be embedded within the existing PLCM.

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WRC Symposium

Ensuring a better water future – together

There was a confluence of stakeholders, technologies and innovations at this year's Water Research Commission (WRC) Research, Development and Innovation (RDI) Symposium, which took place in Birchwood in September this year. Held every two years, the symposium is aimed at creating a space for the exchange of ideas and innovative thinking around solving South Africa's most prominent water challenges.

The theme of this year's conference was 'universal access wherever you are'. The theme implies a rethink of how the sector approaches access in the water and sanitation domain. It acknowledges that access to water and sanitation is not merely a question of infrastructure, but also about access to resources for food security and economic upliftment, integrated policy- and decision-making, and access to water-related knowledge.

Discussions were focused around several themes, including access to a clean environment, access to sanitation, access to drinking water, access to food, and access to water for industrial growth, among others.

"The future of human life on Earth depends on how we manage our water problems today," WRC CEO, Dhesigen Naidoo, explained the symposium objectives. "We are fortunate that we are sitting on a depository of good scientific knowledge and the beginnings of proficient technological solutions. The symposium examined how we are going to bring all of these efforts to bear to organise for the future prosperity of South Africa, Africa, and the world with regards to water."

Another strong objective of the symposium was to strengthen partnerships between key water stakeholders in terms of the sustainable development of water-related solutions. "We are seeking to cement three important partnerships, the first being among scientists globally; the second with the private sector; and thirdly, and importantly, with the users of these services and communities at large to make sure these water solutions are sustainable," noted Naidoo.

This year, the symposium included participation from the Board members of the Global Water Research Coalition, an international water research alliance which serves as a collaborative mechanism for water research. The WRC is one of the founding members of the coalition.

Delegates received a special video message from the Minister of Water and Sanitation, Nomvula Mokonyane, in which she expressed the hope that deliberations during the symposium would lead to RDI playing a bigger role in the lives of especially those South Africans who still lack access to safe water and sanitation. "We need improved mechanisms whereby science and technology can be taken out of the laboratory, into the communities and into the boardrooms where policy decisions are made."

In addition to discussions and debates, the WRC Symposium showcased a number of technologies and innovations stemming from its projects. Technologies and innovations on display included, among others, the Arumloo microflush toilet, the wave energy reverse osmosis pump, Vitasoft process for treating mine-water, the mobile lab, and the water geazer app.

A further highlight of the Symposium was the second WRC Knowledge Tree Awards, which celebrate men and women who have had a major impact in their pursuit for excellence in the water science domain. Recipients were acknowledged based on the impact their research has made in the following categories: transformation and redress, enhancing human capital development in the water sector, informing policy and decision-making, empowering communities, providing sustainable development solutions, and developing new products and services for economic development.

This year's winners were:

- In the transformation and redress category: Prof Leslie Petrik and Dr Barbara Tapela, both from the University of the Western Cape;
- In the sustainable development solutions category: Prof Geoff Pegram from the University of KwaZulu-Natal (UKZN) and Prof Wim van Averbeke of the Tshwane University of Technology;
- In the empowerment of communities category: Associate Prof Ulrike Rivett from the University of Cape Town and Rowena Hay from Umvoto Africa;
- In the informing policy and decision-making category: Prof Olaf Weyl from the South African Institute for Aquatic Biodiversity and Unathi Jack and her team from Emanti;
- In the human capital development category: Prof Albert Modi and Prof Chris Buckley, both from UKZN;
- In the new products and services category: Marco van Dijk from the University of Pretoria and Prof Alison Lewis from the University of Cape Town.

Winners of the WRC Knowledge Tree awards.

Discussing access to services were Doulaye Kone of the Bill and Melinda Gates Foundation, Gislette Philippe of Suez Environment, Dr Nozi Mjoli from Hlathi Development Services, Adam Lovell of the Water Services Association of Australia, and Dhesigen Naidoo of the WRC.

Building international relations were Prof Olaf Weyl of SAIAB, Suresh Kumar Rohilla of the Centre of Science and Environment (India) and Dr Amit Pramanik of the Water Environment Research Foundation (USA).

Liketso Khaile, Sylvia Machimana, and Gugu Motha of the Inkomati-Usuthu Catchment Management Agency were among the delegates who attended the symposium.

Among the delegates were Zukiswa Mbolekwa-Pupuma of Govan Mbeki Municipality, Thokozani Majozi of Wits University, Thokozani Kanyerere of the University of the Western Cape and Bongani Miasi.

Women in Water

DWS to boost women entrepreneurs

Delegates from the Department of Water and Sanitation.

The time has come for women to move beyond carrying buckets to driving, constructing and managing the water resource infrastructure they need.

This was the message from Minister of Water and Sanitation, Nomvula Mokonyane, at the Women in Water Consultative Conference held in Pretoria earlier this year.

Historically, access to water in South Africa, like access to many rights and privileges were determined by the dictates of race and gender. Access to water was further complicated by the link between access to land and access to water. Since access to water is inextricably linked to access to land, the rights of Africans and women's access to water was further limited by their limited access to land, 13% of which was reserved to Africans under apartheid policies and legislation.

While much has changed since that time, business of water lacks women. At an institutional level, the number of women in leadership is miniscule compared to the number of men, noted Mokonyane. "At the community level, those doing the hard work to transport, re-route, or clean water resources are usually women, while management and distribution decision making is often within the male sphere of influence."

But this is set to change, according to Mokonyane. In a moving speech that had the 400-strong audience on their feet, she said that women have to move beyond the 'victim' mentality to become the change they wanted to see. "As women, we need to see ourselves how do we inform, incentivise and invest in women-owned businesses and women leaders in water and sanitation? How do we change the debate from one of victimisation to one of transformational leadership?"

As a first step the Department of Water and Sanitation has launched a three-year Women in Water Programme. The programme comprises a mentorship programme, a women in water business incubator and a women in water forum. The scope of the programme covers all women-owned businesses that are competent and excellent in the provision of services to the Department.

"As women, we need to see ourselves how do we inform, incentivise and invest in women-owned businesses and women leaders in water and sanitation?"

Minister of Water and Sanitation, Nomvula Mokonyane.

Delegates at the Women in Water Consultative conference.

The objectives of this programme are to:

- Identify and address the key gaps between the current scenario and expected future scenario for the participation of women owned businesses in the water sector
- Accelerate the growth and success of entrepreneurial companies through an array of business support resources and services that might include but are not limited to the following: physical space; capital; coaching; common services; and networking connections.
- Develop business talent to enhance performance of women-owned businesses and create readiness for transition to the next level of operation
- Develop a succession and retention plan for women-owned businesses to sustain organisational excellence in terms of service delivery

The beneficiaries of this programme can be categorised into three cohorts, namely beginners (women-owned enterprises in business with no sustainable growth), intermediates (women-owned enterprises in business not yet as established as big enterprises), and established women-owned enterprises at intermediate stages that function as fully-fledged businesses but that require additional assistance to take their business to the next level of operation and compete nationally and globally.

The programme will mainly target women in the spheres of innovation, construction, and local community initiatives, however, other women-owned businesses may also be considered based on merit.

In her conclusion the minister called on women to use this opportunity to not only enrich themselves, but to ensure empowerment and dignity to all those who still do not have access to water and sanitation services in the country. "Women empowerment is not just thinking about yourself, but also about ensuring access to services for others. We need to make sure that Ma Dlamini no longer has to walk long distances to collect water from sources where animals drink; that no woman has to relieve herself outside at night with the fear or being raped or assaulted."

Water resource management

Drought management – Strengthening our knowledge armoury

As South Africa braces itself amidst increasing drought, a present Water Research Commission (WRC) study aims to improve the country's ability to prepare for and mitigate against such climatic events in the future.

Article by Lani van Vuuren.

By the end of October, water in the Hazelmere Dam – which serves residents of the eThekwini and iLembe municipalities – had reached below 29%, forcing the municipality to tighten water restrictions while racing to implement alternative water-supply options. The dam serves as a visible barometer of the intense drought gripping parts of the country at present.

KwaZulu-Natal, Limpopo, North West, Free State, and the Northern Cape have been hardest hit in what has been described as the worst drought to hit the country in 23 years. The South African Weather Service (SAWS) has predicted that the situation might become more precarious as summer progresses amid predictions of above average temperatures combined with lower-than-expected rainfall. The current hot and dry climatic conditions seem to be driven – at least partly – by the strongest El Niño the world has seen since 1997, and which is expected to intensify by the end of the year.

Natural phenomenon

The World Meteorological Organisation describes drought as 'the world's most destructive natural hazard'. Droughts cause the deaths and displacement of more people than cyclones, floods and earthquakes combined, yet effective drought management policies are missing in most parts of the world and, some say, in South Africa.

Droughts are a major feature of the climate of South Africa. As a result of the country's location at the southern tip of Africa between cold and warm sea currents, as well as its topography, South Africa has an extremely variable climate over space and time. Because of these characteristics, the country is considered to have one of the most variable river flow regimes in the world – with drought being one manifestation of this variability.

Along with this climatic variability the country is naturally water scarce. South Africa's average annual rainfall falls well below the world average of 860 mm a year. Further, the distribution of rain varies widely across the country – generally reducing from east to west, with 65% of the country receiving less than 500 mm of rain a year.

The country's semi-arid nature results in much water being lost to evaporation, and in many areas evaporation from the surface exceeds the average annual rainfall. It is estimated that less than 9% of the precipitation that falls on the ground eventually finds its way into South Africa's river systems. This natural water scarcity makes South Africa particularly vulnerable to drought. Vulnerable communities are usually hardest hit as water for domestic use and rainfed subsistence crops dry up and food prices escalate.

Managing water in times of drought

Historically, South Africa has constructed sophisticated bulk water storage and conveyance systems to store water in times of surplus for use in times of need. By the early 2000s, the total storage capacity of the major dams in the country amounted to around 34 million m^3 – or about 70% of the mean annual runoff from the land surface of the country.

Rising water demand as a result of population growth and socio-economic development is placing pressure on many of these systems. As pointed out by the Second National Water Resource Strategy, most of the economically available yield from surface water resources has already been fully developed and utilised, and opportunities for developing new and economic dams are few.

The Department of Water and Sanitation's (DWS's) Water Reconciliation All Town Study has shown that water resources in 30% of South African towns are already in deficit, with water resource shortages expected in another 13% of towns in the next one to five years, and a further 12% of towns in the next five to ten years. This situation has the country's water resource managers walking a constant tightrope between balancing supply and demand, and leaves little room for extreme situations, such as drought.

To manage its sophisticated water supply systems, the DWS makes use of operating rules. Operating rules serve to guide the system operation, not only under normal conditions but, very importantly, also during droughts. They help to inform decisions on whether or not restrictions should be implemented, at what level of severity, when they can be relaxed or when stricter restrictions need to be considered.

During periods of drought, water supply is prioritised in accordance with the assurance of supply of the various water use sectors. Basic human needs and water requirements of strategic users, such as power stations and major industries, are the least curtailed. Urban water users will typically be curtailed at a lesser degree than agriculture. Each specific system will therefore have different levels of curtailment, according to the profile of water users reliant on the system.

Types of drought

- **Meteorological drought** – This type of drought occurs when there is a prolonged period of below average precipitation (usually lower than 70%), which creates a natural shortage of available water.
- **Agricultural drought** – This type of drought occurs when there isn't enough moisture to support average crop production on farms or average grass production on range land. Although agricultural drought often occurs during dry, hot periods of low precipitation, it can also occur during periods of average precipitation when soil conditions or agricultural techniques require extra water.
- **Hydrological drought** – This type of drought occurs when water reserves in aquifers, lakes and reservoirs fall below an established statistical average. This can happen even in times of average or above-average precipitation, if human demand for water is high and increased usage has lowered the water reserves.

Operating rules need to be updated and improved regularly, in response to improved understanding and knowledge of the water resources within the system, and the factors influencing water requirements. It is therefore crucial for water resource managers to keep an ear to the ground, and be provided with the most up-to-date information on a timely basis so that they can adapt their operating rules and so ensure that there remains water in the system for all.

A significant challenge in this regard has been the deterioration of observation networks in South Africa. There are serious concerns about the decline in monitoring of rainfall, streamflow,

groundwater levels, and water quality in South Africa, among others. Rainfall is an important variable through which the availability of water resources is gauged. However, rainfall observation in South Africa has declined to such an extent that the current number of useful rainfall stations we have now (about 700) is less than what we had in 1920. Additionally, the quality of the data from most of the observation networks (rainfall stations, gauging weirs, reservoirs, etc) is largely poor and this suggests the lack of quality control measures which is crucial for the integrity of the datasets.

Towards improved drought risk management

On the upside, since the last significant nationwide drought in 1991/92, South Africa has made positive strides towards improved drought mitigation. This includes the promulgation of the Disaster Management Act of 2002 and the National Disaster Risk Management Framework of 2005. However, despite these policies the focus of the South African government still seems to be largely centred around remedial action rather than on preventative mechanisms.

There is a growing realisation that South Africa requires a long-term, national drought policy and strategy to mitigate the risk of future occurrence of drought, notes WRC Research Manager, Wandile Nomquphu. Particularly, the the Water Research Commission (WRC) has identified the need for science-based mechanisms and monitoring that will deliver timely information to decision-makers and so strengthen risk management measures and preparedness plans.

A three-year project funded by the WRC and undertaken by the University of Cape Town is looking to characterise extensive droughts over southern Africa, and to investigate the mechanism that produce and/or control these droughts. The study is also examining how climate change may influence the characteristics of these regionally extensive droughts in future.

An interesting aspect of this project is its use of the so-called Standard Precipitation Evapotranspiration Index (SPEI) to characterise the intensity, spatial coverage, duration and frequency of droughts. Nomquphu explains that drought monitoring traditionally only measures rainfall, however, this neglects other variables such as temperature, wind speed and direction as well as potential evapotranspiration, which equally have more influence on drought.

The SPEI is a modification of traditional drought monitoring approaches which accounts for the effect of temperature variability in monitoring droughts at different time-scales. "It has the capability to detect temporal and geographical extension of drought," explains Nomquphu.

During the first year of the project, SPEI was used to examine the occurrence of drought in South Africa between 1950 and

Drought – the role of water demand management

While the current drought is beginning to have its presence felt in most provinces in South Africa, the Department of Water and Sanitation (DWS) has called on municipalities to reduce non-revenue water with urgency.

Speaking at the Fifth Regional Water Leakage Summit, held in Midrand earlier this year, Paul Herbst, DWS Director: Water Use Efficiency, said that implementation of water conservation and water demand management (WC/WDM) strategies was now crucial if South Africa was to overcome the current dry spell. WC/WDM was also a critical element in all reconciliation strategies to balance water supply and demand. Yet while some municipalities had made a great start at water conservation, others were not even aware of their current water use and/or water losses. "As a country we need to do manage our water much better," he said.

The department had already started assessment for the new No Drop certification programme that measures municipalities' water loss reduction efforts.

Concern was expressed over available water in Gauteng, where some areas experienced high per capita water use, leaving the Vaal River system under strain. "Unless we change consumer behaviour drastically, the writing is one the wall," said Herbst. "At the current rate of drawdown, if low rainfall persists the Vaal Dam will be dry in two to three years."

Already in October persistent highly high temperatures coupled with low rainfall caused Rand Water to send a warning out to residents in its area of supply. High water demand was projected to cause localised problems in some parts of Johannesburg, Pretoria and the East Rand.

South Africa's rainfed agricultural production, particularly maize, has already been negatively affected by present drought conditions.

A dry Vaal River in 2005 with the Vaal Dam wall in the background.

2013. The research team found that since the 1980s droughts have been occurring more frequently and with greater intensity in South Africa. Where the country traditionally expects large-scale droughts every seven or so years, this has now reduced to every three to four years.

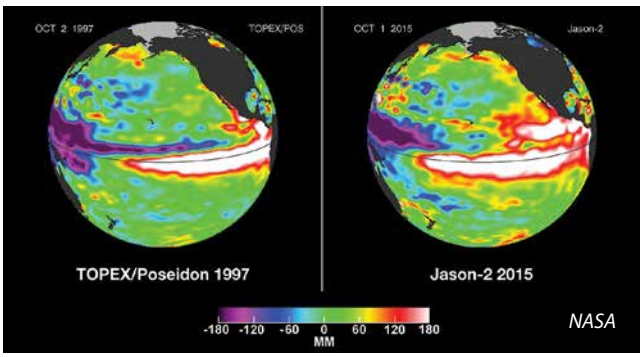
It is uncertain at this stage whether this is as a result of climate change, although the team hopes to answer this question as part of the project. The study will also be assessing the reliability of global and regional climate models in simulating regionally extensive droughts and projecting the impact of climate change on future characteristics of these droughts.

If we are to expect more intense droughts more frequently, interluded by bouts of high rainfall over short periods, South African water resource managers will have to become much smarter about the way they manage and operate South Africa's water systems, notes Nomquphu. "We will have to sharpen our focus in terms of adapting operating rules to fit current conditions, and intensely monitor our weather and water resources so that we can adequately prepare for any change."

"Water users, such as farmers, need to be warned well in time so that they can put proper contingency plans in place. Finally, ordinary South Africans will have to start realising that our water resources are finite and that we all need to do our part to ensure there is water for all."

It is hoped that this project will provide input into the development of a National Drought Policy and Strategy. As part of this project, which will conclude in 2017, an online drought monitoring system will be developed.

In the long term, the key to drought preparedness is to know the what, how and when of upcoming drought, adds Nomquphu. "To achieve this goal the scientific expertise to monitor and predict, the capability of the observation networks, as well as the information systems for early warning have to be improved drastically." To this end, the WRC has commissioned a call to investigate the feasibility of (re)establishing a Hydrology Institute to act as a clearinghouse for all hydrological datasets to support the water sector. The envisaged institute could play a critical role for the water sector in drought monitoring and research.



The 2015 drought in South Africa is said to be driven by one of the strongest El Niño events on record. Every two to seven years, an unusually warm pool of water develops across the eastern tropical Pacific Ocean to create a natural short-term climate change event. This warm condition (i.e. El Niño) spurs extreme weather patterns around the world – including drought in southern Africa. In this side-by-side visualisation, Pacific Ocean sea surface height anomalies during the previous strongest El Niño (1997-98) on the left are compared with the 2015 Pacific conditions (right).

Water history

Molteno – 'Old boy' of Cape Town still in service despite chequered start

Despite its shaky start, the Molteno Reservoir remains a key part of the City of Cape Town's water supply more than 130 years after its initial construction. Arne Singels traces the history of the reservoir and lifts lessons from its construction for today's water engineers.

Wikipedia

"There's a tank as you might say at the back o' that big hotel up the hill – what do they call it? 'The Molteno Reservoir', I suggested and Hooper nodded," wrote Rudyard Kipling.

It is the year 1870 and Cape Town Municipality is one of nine independent municipalities at the foot of Table Mountain. Up to now the town's growing demand for water has been dependent on water available from numerous springs emanating on the lower slopes of Table Mountain as well as from a few streams.

Two reservoirs have recently been built to store enough water to meet the demand during the dry summer months. These reservoirs are rather limited in size, namely 11.4 Ml (1852) and 54.6 Ml (1860). Both are situated at a level of 56.6 m above sea level, being too low to supply the required pressure for the growing reticulation system. They are rather aptly termed the Lower Service Reservoirs.

John Gamble was appointed by the Colonial Government as the first Hydraulic Engineer in the Colony. He was instructed to advise the city on water matters and advocated the construction of a large reservoir on Van Breda's field, at that time situated high above the town. The town decided to build a substantial storage reservoir at a higher level of adequate size to store water from the existing water resources, namely the Stadsfontein, Lammetjie, Vineyard, House, Klein Tuin, Scholtz Klip, Beltz Klip and Verlatenbosch Springs in order to supply the demand in summer. There were also two streams that would supply the new reservoir, i.e. Platteklip and Silwerstroom.

The new storage reservoir would be sited near the De Waal Park, Gardens well above the current City Centre.

Construction and initial failure

The town was experiencing rapid growth and water demand continuously exceeded the supply.

Severe water restrictions were the order of the day. In 1877, several Bills were passed by Parliament empowering the city to acquire the necessary land, a portion of the *Oranjezicht* Farm, from Mr Van Breda to build a reservoir at the top water level of 92.5 m above sea level. The new reservoir was designed under the supervision of James Tennant, the Town Engineer at the time. A contract for £98 000 was awarded to William James

in 1877 for the construction thereof. The reservoir dimensions were 300 m long, 92 m wide and 15 m deep, with an approximate capacity of 227 Ml.

The sandy soil found on site was not ideal for such a water retaining structure. The reservoir was constructed by a cut-to-fill process, with embankments on three sides. The structure was completed by March 1881 and the first water was impounded on 4 May 1881. Whilst filling to about 500 mm a wing wall to the valve shaft fell over. The Town Engineer, J Stuart Swallow, proposed the abandonment of the revetment walls and constructing a culvert from the valve shaft to a fore bay in the reservoir. Despite not being filled, the official opening of the new reservoir by Sir John Molteno, the first Premier of the Colony after whom the reservoir was named, took place on 21 July 1881.

Filling then proceeded slowly and at about 3 m depth a leak appeared in the tunnel and the water level was reduced in response. A portion of the clay puddle behind the valve tower was removed and a man-sized gap was found running along the top of the outlet culvert. This was filled with puddle clay, which had to be compacted horizontally in very limited space – a very unsatisfactory process according to a Charles John Wood, who was subsequently appointed by the City.

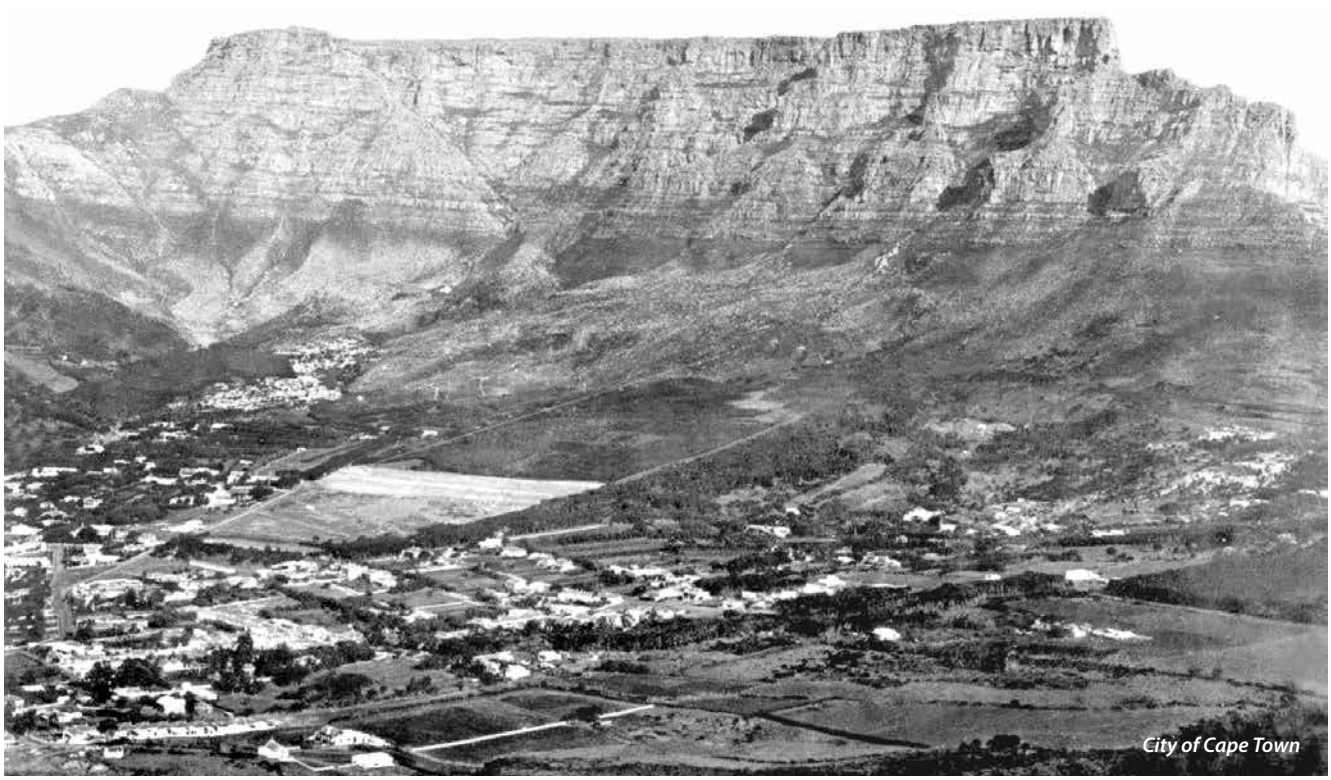
Behind the shaft concrete was placed and the puddle relaid to the top of the embankment. Filling commenced again on 21 September 1881 up to a level of about 3.8 m. Further filling proceeded on 2 April 1882 i.e. the following year, but on the 26th of the month when a depth of 4.3 m was reached a new leak was found.

An inspection hole was sunk over the culvert near the puddle-core and a 40 mm crack through the puddle was found as well as a space through the clay-core above the culvert of up to 450 mm. These were filled and water was again introduced to the reservoir to a depth of 8.2 m, when yet another leak commenced. It was found that the brickwork of the tunnel had been laid so badly that streams of water poured through the pointing disintegrating the puddle. After repair the reservoir was filled up to 10.7 m, which was later reduced to 9.5 m where it remained for three weeks and all seemed well.

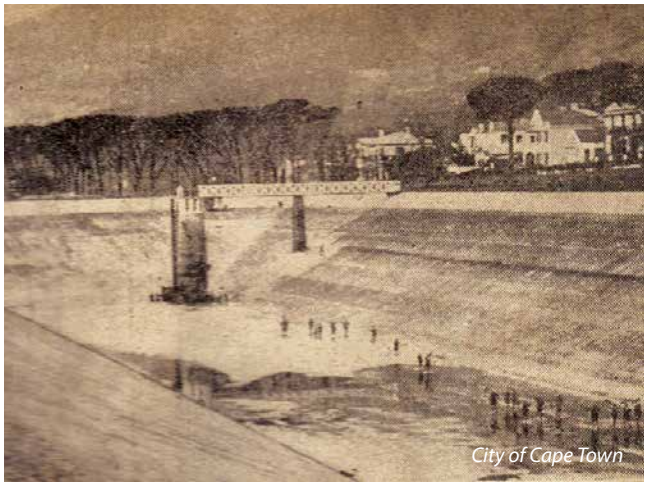
At midnight on Thursday, 23 August, a night watch reported a serious leak, but this stopped almost immediately. Precautionary measures were taken by keeping bags of clay near the valve-shaft to effect quick repairs and the water level was once again reduced and the filling stopped. Men were put in constant attendance. All went well whilst the reservoir was dropping steadily, until the morning of Sunday, 27 August 1882.

The leak broke into the culvert and carried away the filling-in around the culvert, with a resulting flood into the City streets. As the leak had commenced at the side of the shaft at a high elevation the flow was checked fairly rapidly using bags of clay that were at the ready, due to the first alarm. The flood was stopped with difficulty but relatively quickly with 6.1 m of water still remaining, preventing more extensive damage.

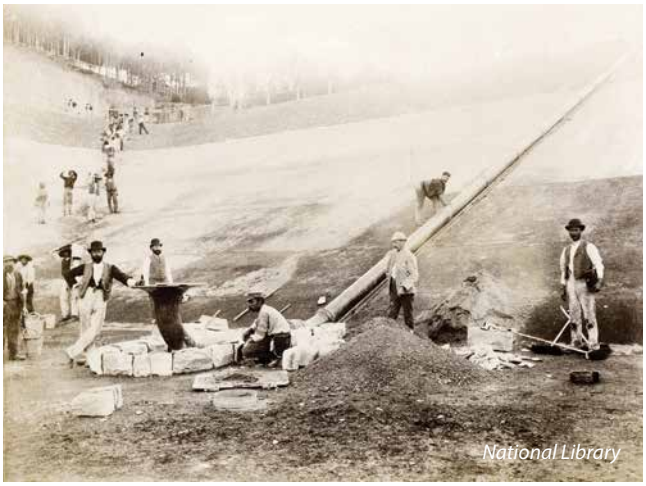
No lives were lost, but Oranje Street was turned red and the flooding impacted the city while church goers were making their way back to their houses. A garden



The Molteno reservoir under construction in 1877.



This sketch of the reconstruction of Molteno Reservoir appeared in the press in 1885.



The Molteno Reservoir being repaired following its failure in 1882.

wall collapsed, a light cart overturned and furniture in houses below the reservoir was damaged. It was further reported in the newspapers that certain roadways had deep ruts in them due to the flood water and that pipe bursts caused by undermined pipework were being repaired by municipal staff.

The reservoir where the leak had occurred was visited by many inquisitive citizens. By 10 July 1883 the reservoir was emptied through controlled consumption. The loss of water was not the only complaint about the reservoir. Residents in the neighbourhood complained about the general leakage doing damage to their properties situated below the reservoir and were very much against the City attempting any further repairs or filling of the reservoir and it remained empty for over a year.

The City then approached the Institution of Civil Engineers (United Kingdom) to select an engineer to advise on the causes of the failure and a method of repair. The task was offered to Charles John Wood, who subsequently arrived in Cape Town from Britain on 21 January 1884, was appointed by the city to report on the failure and to propose remedial work to render the reservoir serviceable. He reported to Council by March the same year.

Analysis of failure

In his report to the City, Charles J. Wood states quite correctly that it is more difficult to repair a reservoir which, for whatever reason is not watertight, than to do the work ab initio. Regarding the water tightness of the reservoir he states that he is convinced that most of the leakage occurred through the floor and was due to unsuitable material for a pressure of about 14 m of water. The 610 mm puddle that was used in the floor was inferior, half-worked and could hardly be distinguished from the floor material.

Similarly, the 300 mm puddle on the slopes was hardly discernible. Furthermore, the ends of the embankments had not been tied into the hillside and the puddle trench should have extended 6.1 m deeper than was constructed. The clay was found to be unreliable and not well worked and, in fact, no suitable clay could be found in the area.

Wood also found that the bursting of the reservoir along the culvert was caused by the over-excavation through the undisturbed ground under the embankment for the culvert. After the construction of the tunnel, the surrounding space had been filled in by labourers who worked without proper supervision and executed the work poorly. This caused the settling of the puddle-core and the occurrence of cracks which resulted in the leakage.

He recommended that 610 mm-thick Portland cement concrete be used to line the floor of the reservoir and the slopes to a level of 2.44 m above the floor. For the next 6.7 m, 460 mm-thick concrete was to be placed on the slopes up to 4.5 m below Top Water Level. Above this the embankment slopes had to be cut back by about 910 mm, the original puddle had to be reworked and replaced, a 300 mm layer of gravel placed and stone pitching added. This was then to be blinded with gravel.

A cut-off wall was to be built around the culvert and a second cut-off 1.22 m thick at the existing puddle trench backed up by a reworked puddle.

Regarding the Eastern culvert and embankment, he proposed that the whole culvert be excavated to invert level and a new one be constructed, founded and surrounded by concrete. The old valve shaft was to be demolished and a new one erected with brickwork and cement mortar further into the reservoir.

Access was to be provided by means of a Warren girder bridge, the one visible today. He also suggested a stone wall at the top of the embankment (North & West sides) to prevent the South-Easter storm winds from blowing water over the embankment and damaging it.

Wood also concluded that the embankment of the Molteno Reservoir was of "enormous strength and proportions," and thus inherently stable. His repair works therefore focussed on making the reservoir waterproof.

During the reconstruction work required, Wood emphasised the need for a competent Inspector of Works and a dedicated Resident Engineer to oversee the works – an element sadly lacking in the original construction of the reservoir. The reservoir was to be filled incrementally after completion of the works. The initial filling would be to 9.1 m in the first year and then 1.5 m for each successive year, with continuous thorough inspection of the structure.

Reconstruction

After a year's delay due to uncertainty, the recommendations of Charles John Wood were accepted and a contract was awarded in 1884 to a local firm, Messrs Ball & Smart, to repair the structure for £35 000. The repairs took 18 months, the cost of the contract was £37 346 7s 2d and final completion was in 1886.

At the beginning of June 1888 the reservoir was thoroughly cleaned during which concrete lining was found to be faulty in places. Three concrete experts were called in to report on this and 19 test holes were made in the lining, although the City Engineer found this inadvisable as he felt that any breach could not be restored to its original state.

The experts concluded from the test holes that the concrete was not strictly in accordance with the requirements of the contract. The reservoir was, however, refilled to about 125 Ml with no sign of leakage. In the Mayor's Minute of the year ending September 1889 it was mentioned that, after the construction and completion of the reservoir, a small stream of water had been noticed at the side of the reservoir.

Wood was of the opinion that this was drainage water from the mountain being impeded by the reservoir. Others thought that this was a more serious leak from the reservoir itself. When the reservoir was empty, the stream was measured at 196 kl per day and with the reservoir full it remained the same, supporting Wood's theory.

Further work was done on the embankments. The City Engineer's Annual reports of 1907 and 1910 state that the embankments of the Molteno reservoir were repaired in places. The pitching of the internal surfaces was grouted to about 150 mm above the high water mark and further grouting was to be executed on the slopes three years later.

Modern status

When the Molteno Reservoir was emptied in 1976 the slopes of the reservoir were lined with a concrete layer about 45 mm thick. This layer extended to above the Full Supply Level, over the original concrete slab(s) and the stone pitching above them.

The first dam safety inspection was conducted in August 1989. When a geotechnical investigation was undertaken in 1983 as part of a proposal to construct a roof over the reservoir, a number of trial holes were excavated through the concrete lining. These generally showed the lining to consist of a 500 to 600 mm layer of cement stabilised gravel covered by a 75 mm-thick concrete layer.

The question of roofing the open (now treated) water reservoir has been an ongoing debate which was started by the Medical Officer of Health in 1904 when he recommended that the reservoir should be covered. He commented that the township above the reservoir was "not a source of comfort".

Covering the reservoir was considered at the time by the City Engineer, RO Wynne-Roberts, but it was found to be too expensive and was deferred. For many years, every junior engineer joining the Waterworks Branch of the City of Cape Town was given the task of designing a roof structure for the Molteno Reservoir.

The last effort was in 1983, when Peter Roux under the guidance of JG Welsh undertook an in-depth investigation, which included an option to accommodate sports fields on the roof for a nearby school. Apart from being very expensive, the main engineering problem was the lack of loading capacity of the in-situ material for the column foundations. The covering of the reservoir would be a controversial option if it had to be done today and would attract considerable resistance from the property owners in the immediate vicinity. For now, this option is still being deferred.

Lessons learnt

The shape of the Molteno Reservoir and the cut-and-fill method has been repeatedly used for a large number of the City of Cape Town's more modern service reservoirs. The obvious difference in these reservoirs is the fact that roofs are provided to protect the water quality. Another improvement is the use of underdrainage systems enabling reservoir floor leakage to be measured and floor integrity monitored.

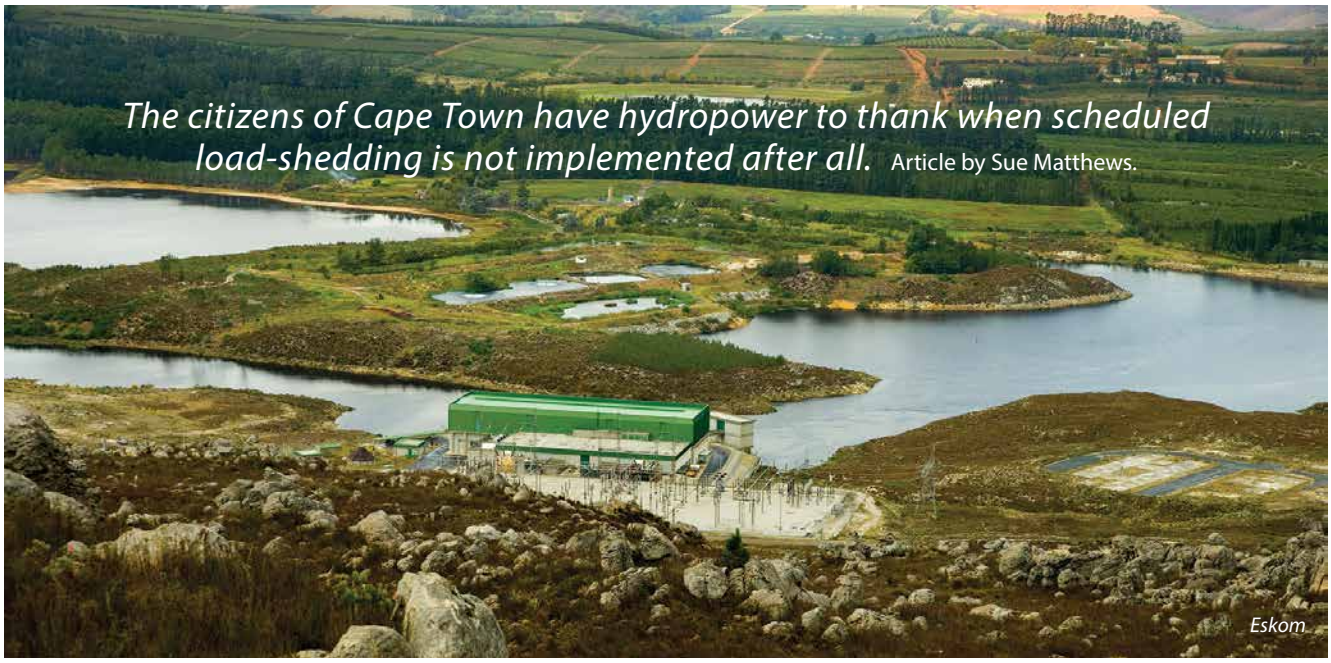
This was probably the first lesson learned from the Molteno failure. For the construction of any large bulk water infrastructure executed under contractual arrangement (the Waterworks Department constructed a number of significant structures internally) the Bulk Water Branch has consistently assigned a full-time dedicated Resident Engineer and Assistant Resident Engineer from its own staff. This has ensured the quality of workmanship and has no doubt prevented potential disasters such as were experienced with the original Molteno contract. This is a most valuable lesson to learn and an approach not to be deviated from in future.

This article was extracted from a paper presented at the SANCOLD Annual Conference 2015.

The Molteno Reservoir with the De Graaf Electric Lighting Works in the background.

Water and energy

Hydropower – keeping the lights on in the Mother City



The citizens of Cape Town have hydropower to thank when scheduled load-shedding is not implemented after all. Article by Sue Matthews.

The Palmiet Power Station lies next to the Kogelberg Dam on the Palmiet River.

Mention pumped-storage hydroelectricity to most Capetonians and they'll either look at you blankly or say, "Ah yes – that Eskom place at the top of the pass." They're referring to the Palmiet Pumped Storage Scheme, which they've probably noticed while driving over Sir Lowry's Pass, the section of the N2 national road that crosses the Hottentots-Holland mountains separating the Cape Flats from the Overberg beyond.

All that can be seen from the road is the visitors centre, some power lines and – in the distance – the Rockview Dam wall and an incongruous-looking tower, which is actually a surge tank preventing excessive fluctuations in pressure when water flow suddenly stops or starts. Out of sight in a valley is the Kogelberg Dam on the Palmiet River, and the 400 MW power station with its two reversible pump-turbines, which act as a pump-motor in one mode and a turbine-generator in the other. Power is generated during periods of peak energy demand, when water is allowed to flow down an underground tunnel from the Rockview Dam to the Kogelberg Dam. When demand is low, water is pumped back up the tunnel to the Rockview Dam, so it can be used again. But for every 10 hours of electricity generation, approximately 15 hours are needed for pumping.

"We don't get all the water back up every night so water steadily accumulates in the lower dam during the week," says Liesel Sherwood-Adcock, information officer at the visitor's centre. "At weekends we must pump, using electricity from the grid, to build up reserves for the coming week."

This is why Eskom sometimes says load-shedding is being done at the weekend to 'replenish reserves' – they need to provide enough electricity to pump all the water back up to Rockview Dam so that it's available for generating during the week, when demand is high.

Commissioned in 1988, this was the second pumped storage scheme developed by Eskom in a joint venture with the Department of Water Affairs. The 1000 MW Drakensberg scheme was put into commercial operation in 1981. But the first pumped storage scheme in the country – in fact the first on the African continent – was the 180 MW Steenbras Power Station constructed by the City of Cape Town. It was commissioned during 1979, and has been in operation ever since, yet few Capetonians even knew of its existence until it saved them from load-shedding a few times this past winter!

From the outset, the Mother City was at the forefront of the hydropower field. Although two 6 kW hydroturbines were

in use in the gold mines of Pilgrim's Rest as early as 1892, the Graaff Electric Lighting Works inaugurated in 1895 on the lower slopes of Table Mountain is considered South Africa's first hydro-electric power station. Built next to the Molteno Reservoir, its two 150 kW generators could be driven either by steam or by water flowing from the Woodhead Reservoir on the 'table top'. It was closed in 1920, after coal-fired power had become the mainstay of the city's electricity supply.

In 1974 the city entered into a long-term bulk-supply agreement with Eskom, but this electricity is expensive during peak periods because the 'night-save' tariff means that the city is charged according to the maximum demand attained in any given month. The possibility of a pumped storage scheme to augment the city's power supply had been bandied about since the 1950s, so it was decided to construct one to reduce the amount of electricity purchased from Eskom at peak rates – a process known as 'peak lopping'.

There was already a dam on the Steenbras River, which – like the neighbouring Palmiet River – drains the Hottentots Holland mountains and flows under the N2 on Sir Lowry's Pass. Completed in 1921, it initially delivered water to the Molteno Reservoir through a 64 km-long cast-iron pipeline. The dam wall was raised in 1926 and again in 1954, and during this period two additional pipelines were laid to the Newlands Reservoir, just over 50 km away.

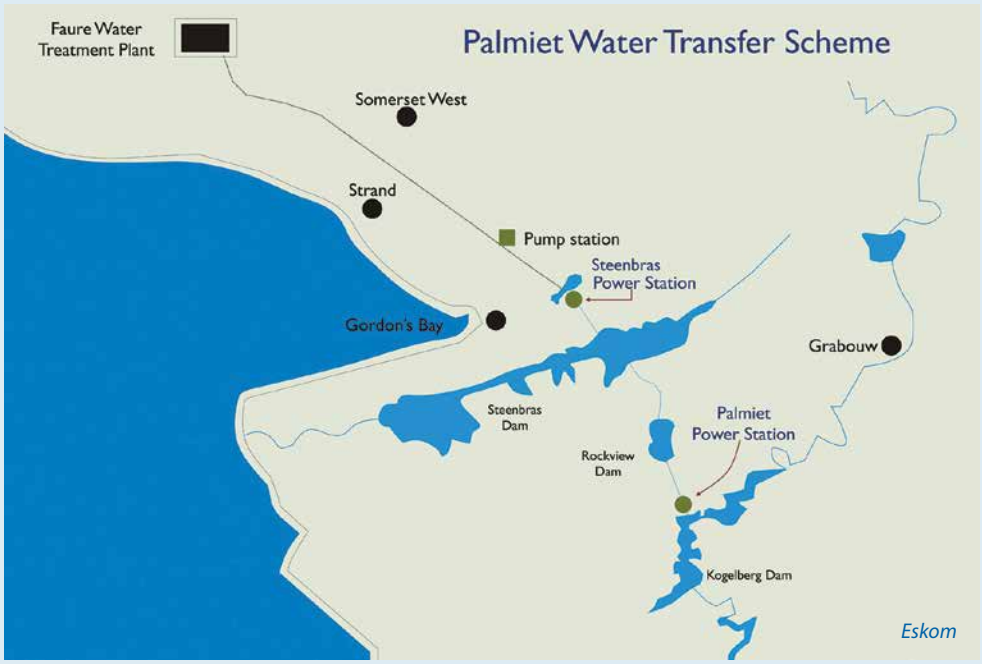
A second dam was built upstream of the existing Steenbras Dam, and the intake works for the pumped storage scheme sited in this 'upper' dam. A small reservoir and the power station were constructed on the mountainside some 300 m below, and the two water masses were connected via a series of tunnels and a steel penstock that splits just behind the power station to deliver water to the four 45 MW pump-turbines.

Operation is essentially the same as in the Palmiet scheme, generation taking place during periods of peak demand around sunrise and sunset, and pumping of water from the reservoir back to the upper Steenbras Dam at night and weekends, using comparatively cheap Eskom electricity. The power station is used as the regulating station on the city's electricity distribution network, ensuring that the feed from Eskom is kept within a predetermined level. The beauty of such installations is that they can be brought online within a few minutes – compared to about eight hours for a coal-fired power station – so generating can begin as soon as that level is reached on any particular day.

Their output is of course constrained by the time taken to pump water back up, but while management of the Palmiet scheme is largely dependent on the storage capacity of the upper Rockview Dam, the opposite is true at the Steenbras scheme. Only about 10% of the capacity of the upper Steenbras Dam is required for the pumped storage scheme, and its daily operation causes the water level to rise and fall by less than a metre when the dam is full.

"In our case, the bottleneck is the lower reservoir," explains Bongani Sithole, head of electricity generation at the City of Cape Town. "If we ran all four units for about 12 hours without pumping any water back up, the reservoir would be full."

The storage capacity of the reservoir was increased slightly in 1988 so that the power station could meet weekly energy requirements, given the limited pumping time available during weekday nights. The reservoir reaches a maximum level by Friday night, but by 6 am on Monday



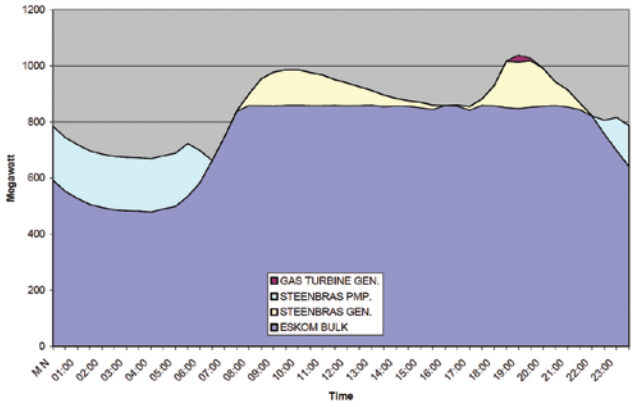
The Palmiet and Steenbras pumped storage schemes are linked by the Palmiet Water Transfer Scheme, which allows excess winter flow in the Palmiet River to be pumped from the Kogelberg Dam to the Rockview Dam, from where it is released to the upper Steenbras Dam. After being used for electricity generation at the Steenbras Power Station, the water is piped to the Faure Water Treatment Plant to augment Cape Town's water supply.

morning it should be empty, ready to start receiving water from the upper dam.

Typically, generating is done for four to five hours per day during the winter months, but this can be extended to eight hours depending on the level of the reservoir. By having its own generating capacity, the city can sometimes also avoid load-shedding implemented by Eskom, or reduce from Stage 2 to Stage 1. Electricity can also be provided to priority installations such as key hospitals and some large factories that cannot risk a power cut.

"We can't do it for too long, because we must always keep enough space available in the reservoir for the water required for routine generating," explains Sithole. In essence, it would not make financial sense to fill the reservoir to a level that would compromise the peak-lopping function, because the city would not be able to recover the funds spent on the more expensive Eskom supply when the baseload limit is exceeded.

The exception to the rule of pumping water back to the top of the mountain occurs when the upper and lower Steenbras Dams are overflowing. The sluice gates of the power station's



Electricity demand and supply components for a typical winter's day in Cape Town in June 2005, showing electricity generation by the City of Cape Town's Steenbras Power Station once the baseload limit is reached during the day, and electricity usage for pumping water back to the upper Steenbras Dam overnight. If necessary, gas turbines at Roggebaai and Athlone are brought into operation too, but fuel costs make this an expensive option. Nowadays, 'peak-lopping' is implemented at around the 920 MW mark, and the total demand may reach 1200 MW.
(Source: City of Cape Town)

A rocky ridge of the Hottentots Holland mountain range separates the upper and lower Steenbras Dams from Gordon's Bay. The Steenbras Water Treatment Plant is perched on the mountain slope in the foreground, while the reservoir for the Steenbras pumped storage scheme can be seen in the distance.

Bongani Sithole, head of electricity generation at the City of Cape Town, in front of the Steenbras Power Station's SCADA system. (Credit: Sue Matthews)

reservoir are then opened, and generation can take place without being constrained by the capacity of the dam, and without the need to pump water back, which saves on electricity costs. Originally this 'free' water was discharged to the sea at Gordon's Bay, but the commissioning of a pump station below the power station in late 1997 allowed it to be piped instead to the Faure Water Treatment Plant, some 18 km away.

This is the largest of the city's 12 water treatment plants, capable of treating 500 Mℓ per day. It also receives water from the Riviersonderend-Berg River Government Water Scheme, while water from the Steenbras Dam actually forms part of a water transfer scheme associated with the Palmiet Pumped Storage Scheme. In February 1995, the then Department of Water Affairs (now the Department of Water and Sanitation) approved Palmiet Phase 1, which allows the annual transfer of 22 Mm^3 from the Palmiet River – via the Kogelberg and Rockview Dams – to the upper Steenbras Dam.

"Palmiet water is only transferred to Steenbras during the winter rainfall months," explains Sherwood-Adcock. "The Department monitors flow coming down the Palmiet River, and advises us when to pump additional water from Kogelberg to Rockview."

The Rockview Dam lies on the watershed between the Palmiet and Steenbras catchments, so the water flows under gravity when it is released to the Steenbras Dam, less than 3 km away. While this water augments Cape Town's water supply, it is of relatively small importance, making up only 5.6% of the city's total allocation from the Western Cape Water Supply System. The upper and lower Steenbras Dams together contribute 40 Mm^3, representing 10% of the city's allocation.

Apart from the water transferred to Faure for treatment, the Steenbras Water Treatment Plant built below the lower dam in 1946 treats up to 150 Mℓ per day. Even here, hydropower has been innovatively used. Way back in 1948, two turbines with a combined capacity of 340 kW were installed on the inflow pipes. Although only one is operated at a time, this generates enough electricity to meet all the needs of the water treatment plant.

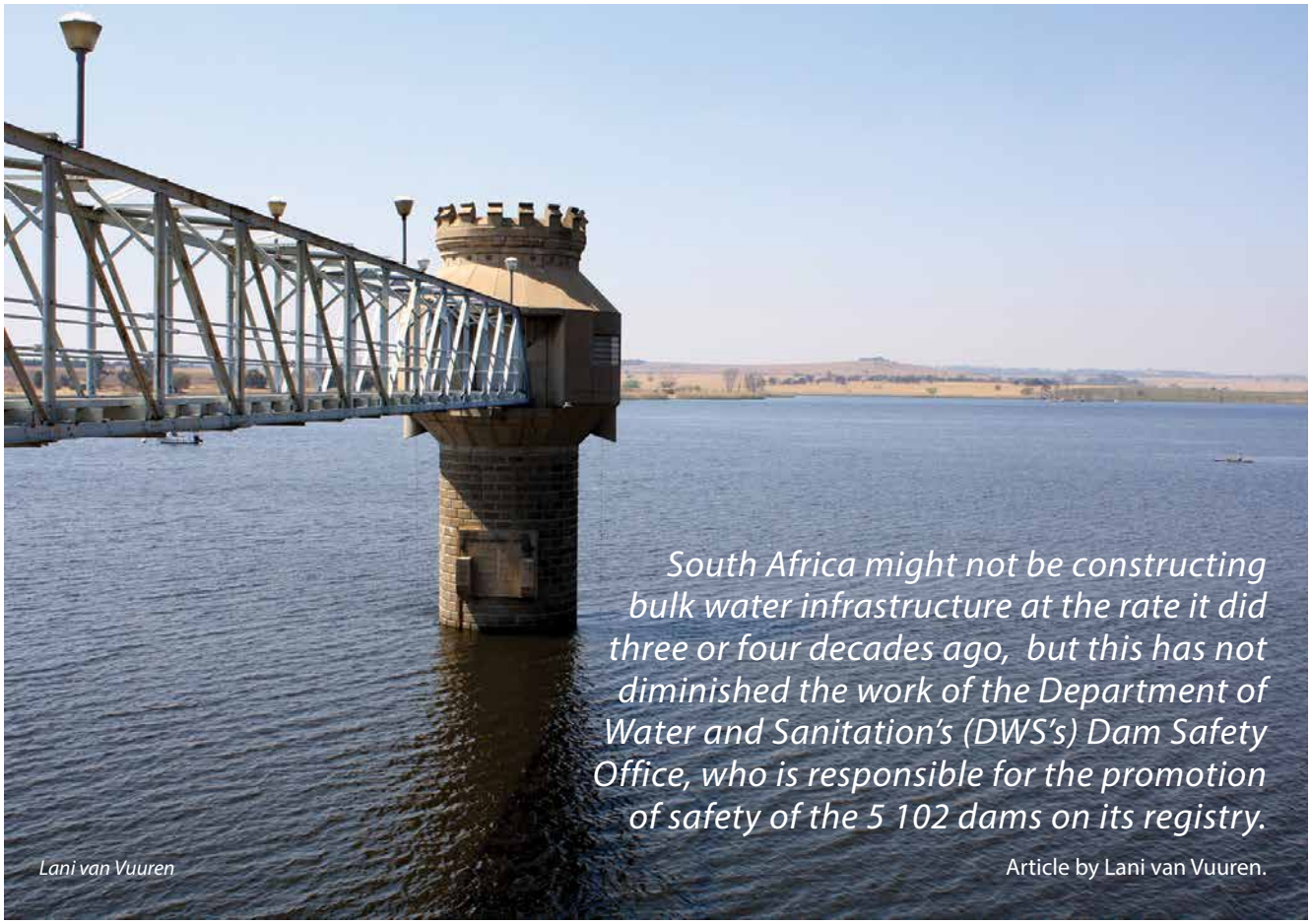
There are similar installations at the city's Faure, Wemmershoek and Blackheath water treatment plants, although at the last-mentioned the turbines are run off the flow of treated water entering a reservoir, rather than raw water from the supply dams.

The city has also been exploring the use of conduit micro-hydropower for remote pressure management instrumentation. Controlling pressure in a water distribution system, for example, is vital in preventing pipe damage and reducing leakages, which can result in costly repairs and water losses. Normally this is achieved with pressure reducing valves, installed at specific points along a conduit to dissipate excess energy, but conveying the water through a turbine instead allows this energy to be converted to usable power. The associated savings in electricity can offset operational costs significantly.

For more information on this aspect of hydropower, refer to the *Conduit Hydropower Development Guide* published by the Water Research Commission in 2014 (**WRC Report No. TT 597/14**).

Dam safety

Dam safety – ensuring the integrity of SA's 5 000+ registered dams



South Africa might not be constructing bulk water infrastructure at the rate it did three or four decades ago, but this has not diminished the work of the Department of Water and Sanitation's (DWS's) Dam Safety Office, who is responsible for the promotion of safety of the 5 102 dams on its registry.

Lani van Vuuren

Article by Lani van Vuuren.

Characterised as a semi-arid country, South Africa is extremely dependent on its dams for water supply. In addition to an annual rainfall that comprises only half the global average, the country suffers from high evaporation rates (a result of its abundant sunshine). On average, less than 9% of precipitation that falls on South African soil eventually reaches the country's river systems. Rain is also unevenly spread across the country, with 60% of the total annual runoff arising in only 20% of the surface area (mostly the eastern part).

Since rivers provide South Africa's only large-scale resources of freshwater, the country has had no choice but to construct storage dams to provide reliable supply of water for its various purposes. South African dam builders have mastered the art and science of manipulating water flows to allow the country to unlock its economic potential.

At last count the country had a total mean annual runoff of only 49 210 million m^3/year. Of this volume, around 70% is stored behind the country's 252 largest dams. The country's bulk water supply infrastructure is integrated and sophisticated, often involving numerous large dams, pipelines, pumps and water transfer schemes from water-abundant to water-scarce catchments.

Ensuring the integrity of this infrastructure is extremely important, especially considering the fact that most of the country's larger dams are now older than 30 years. The DWS Dam Safety Office was originally established in 1986 as a technical unit to support the implementation of dam safety legislation.

Registration of dams with a safety risk

Not all dams in South Africa are registered with the Dam Safety Office. Only dams with a considered safety risk need to be registered. These are dams with a wall height exceeding 5 m and a storage capacity greater than 50 000 m^3. Any structure capable of diverting or storing water is classified as a dam, and so the dam safety register also includes, for example, mine tailings dumps, pollution control dams and potable water reservoirs that fit the classification.

In exceptional cases, the Minister may also declare a dam as having a safety risk even if it falls outside the conventional registration parameters. Every dam with a safety risk must be classified as a Category I, II or III dam (with I being the lowest risk and III being the highest risk). This is done on the basis of the dam's size and its hazard potential rating. Only 6% of South African dams have a Category III rating.

No person who intends to construct a new dam with a safety risk, or enlarge, alter or repair an existing dam with a safety risk, may begin construction work before he or she is in possession of a licence to do so. The Dam Safety Office considers and issues between 20 and 30 licences a year.

All new dams also require a water use licence for the water use activity to store water, as well as an environmental authorisation.

"The licensing system has resulted in a significant improvement in the documentation of dam designs, as well as a significant improvement in the quality of professional persons involved in the process. As a result, the general safety of South African dams has also improved," notes Leo van den Berg of the Dam Safety Office.

This is illustrated by the fact that not a single Category II or III dam for which a licence to construct was issued and which was built under the supervision of a suitably qualified professional has failed since 1987.

Who owns the dams in South Africa?

The DWS dams database contains information on each dam with a safety risk. For each dam the following information is recorded:

- The coordinates of the dam (latitude and longitude)
- The name and contact details of the owner
- Capacity, maximum wall height and classification.

The database is integrated into DWS Geographical Information System (GIS) tools so that the Dam Safety Office can see the position of any dam on a computer screen on a 1:50 000 map and on satellite images in different years. Google Earth is also used.

According to Van den Berg, parameters such as property description, drainage area numbers, contours and elevation data as well as the name and alignment of watercourses are readily available on these GIS systems. At present, the office has 5 102 dams registered on its database.

Of these dams, 75% or 3 832 are small (less than 12 m). Only 3.5% of dams on the register are larger than 30 m. Further, it is interesting to note that the vast majority of dams on the register are located in the Western Cape (1 444), followed by KwaZulu-Natal (986), and Mpumalanga (507). As expected the arid Northern Cape has the least number of dams on the register – only 2% or 82.

Since most of the water in South African dams is used for agriculture it stands to reason that this sector owns the most of the dams on the Dam Safety Register (a total of 4 001 or 80%). Interestingly, the mines & industry sector owners slightly more dams than does the DWS, 337 compared to 324 owned by the

Table 1: South Africa's ten largest dams in terms of storage capacity

Name of dam	Completion date	River/watercourse	Wall height (m)	Capacity ('000 m^3)
Gariep	1971	Orange	73	5 342 932
Vanderkloof	1977	Orange	108	3 187 557
Sterkfontein	1980	Nuwejaarspruit	97	2 616 000
Vaal	1938	Vaal	63	2 536 000
Pongolapoort	1973	Phongolo	89	2 445 900
Bloemhof	1970	Vaal	34	1 269 000
Theewaterskloof	1980	Riviersonderend	35	480 406
Kwaggaskloof/Brandvlei	1983	Breede	25	459 000
Heyshope	1986	Assegaai	29	453 440
Woodstock	1982	Tukhela	54	373 000

Source: DWS

department. The department does own the largest dams in South Africa, however. South African municipalities own a further 321 dams, with the remainder of dams being owned by other government departments and water boards.

New dam safety regulations

Dam safety legislation was first implemented in South Africa in 1987, under the old Water Act of 1956. When this Act was replaced with the new National Water Act in 1998, this legislation had to be renewed. The new dam safety regulations were published in 2012.

According to Van den Berg, the new regulations are better aligned with current legislation. "Experience gained since 1987 was used to improve the regulations. However, the basic principles of the 1986 dam safety regulations have been retained."

The purpose of dam safety legislation was, and still is, to improve the safety of new and existing dams with a safety risk so as to reduce the potential for harm to the public, damage to property or to the quality of water resources. The biggest change to the legislation has been that in addition to protecting human lives and property against unsafe conditions at dams, the new Regulations have been expanded to also protect water resources by assigning a high priority to e.g. pollution control dams, which have an impact on groundwater and surface water resources. These dams occur mostly in the mining, industrial and municipal sectors.

Category II and III dams must be inspected every five to ten years. This, and other dam safety-related work, must be done by approved professional persons or APPs. These are people registered as professional engineers, technologists or technicians who have the approval to perform certain dam safety tasks. Approvals are undertaken in consultation with the Engineering Council of South Africa (ECSA). The new Regulations saw the establishment of a register of APPs, which makes it easier for dam owners to find person(s) with the necessary qualifications.

However, as with many technical skills in South Africa, the list of people undertaking this work in South Africa is small. The Dam Safety Office has also expressed its concern over the availability of APPs. Currently there are less than 100 APPs in South Africa (approximately 1 qualified person for every 50 dams on the Dam Safety register). More than 66% of these are older than 60 years of age.

"[It is clear] that not enough young professionals are being trained to become APPs, and the Dam Safety Office expects that the availability of APPs will soon become a bottleneck for the effective implementation of the compulsory dam safety evaluations of Category II and III dams," reports Van den Berg. This lack of capacity can already be seen in the fact that during 2014/15, only 58% of targeted dam safety inspections were performed.

Capacity is also limited within the Dam Safety Office, who only has a staff of 13 (including administration staff).

Table 2: Distribution of registered dams according to size class

Size class	Number	%
Small (less than 12 m)	3 832	75,1%
Medium (12 m to 30 m)	1 093	21,4%
Large (30 m and higher)	177	3,5%
Total	**5 102**	**100**

Source: DWS

Table 3: Distribution of type of ownership of registered dams

Ownership sector	Total number of registered dams
Agriculture	4 001
Mines, industries and business	337
Department of Water and Sanitation	324
Municipalities	321
Other state departments	68
Water boards	51
Total	**5 102**

Source: DWS

Nqweba Dam outside Graaff-Reinet is one of the oldest municipal dams on the Dam Safety Register, having been completed in 1925.

"The licensing system has resulted in a significant improvement in the documentation of dam designs, as well as a significant improvement in the quality of professional persons involved in the process."

"As long as the number of engineers in the Dam Safety Office is not increased, the office will only be able to do an in-depth evaluation of a small sample of the evaluation reports submitted, for example, only for dams with a high hazard potential, or for dams with a history of unsatisfactory behaviour, or those reports submitted by less experienced APPs," says Van den Berg. "The technical capacity of both the Dam Safety Office and the pool of APPs will have to be increased to meet the ideal long-term target of 292 dam safety evaluations per year."

Implementing dam safety recommendations

Some dam owners respond positively to dam safety inspections by implementing important recommendations promptly. Unfortunately there are also those dam owners who allow dam safety evaluation reports to gather dust.

The Dam Safety Office aims to follow up all cases where instructions have been issued and where important recommendations of dam safety evaluation reports have not been implemented. This objective has, however, not been achieved in all cases due to the shortage of technical and administrative staff. In the case of priority dams, provincial offices of the DWS and catchment management agencies have been requested to become involved in compliance monitoring.

DWS dam safety rehabilitation programme

In addition to the inspection of dams, the DWS has also been undertaking a major rehabilitation programme on its own dams. Over the last six years, the department spent between R385-million and R228-million on rehabilitating dams. Around 50% of dams earmarked for major rehabilitation work have now been completed.

This article is based on a paper delivered at the SANCOLD Annual Conference 2015

Water history

New JHB water history publication fresh off the press

A new publication on the role of water in the history of Johannesburg has been published by the Water Research Commission (WRC).

Article by Lani van Vuuren.

To order the book, *Johannesburg: Gold in the Rand, Water from the Land*, contact Publications at Tel: (012) 330-0340; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download an electronic copy.

The book, *Johannesburg: Gold in the Rand, Water from the Land*, is the second in the Hydrological Heritage Overview series. The first publication – published in 2013, featured the role of Pretoria's Fountains in the founding and development of South Africa's capital city.

The City of Johannesburg currently serves around 4.5 million a day with potable water. The water demand is around 560 billion litres per year and growing. To stay ahead of demand, the city is actively pursuing alternative water-supply options, including rainwater harvesting, water reuse and groundwater, among others. The book takes the reader on a journey from the formation of the area's gold-bearing geology, to the founding of the mining town, and the development of its water resources, to the challenges the city – now an African economic powerhouse – faces today.

Author Dr Matthys Dippenaar from the University of Pretoria, provides motivation behind this project: "Given the very positive reaction to the outcomes of the Pretoria project, it was decided to expand the series to other major South African cities. Johannesburg was selected as the next city to be featured in the series, along with Cape Town [the latter publication is still in production]."

The project was initially focused on groundwater, which played a significant role in the early days of Johannesburg's development, however, it was soon realised that, as a major city not located near a water resource, the city had a richer water history to be explored.

In the last few years, Johannesburg has experienced much negatively publicity surrounding its water challenges such as the impact of mine-water. "With this publication we wanted to illustrate that Johannesburg is not an environmentally-unfriendly city focused solely on mining, industry and commercial activity, but a city with highly-skilled scientists and engineers who have done an excellent job in supplying the city's residents with high-quality drinking water," notes Dr Dippenaar.

The publication provides a broad overview of Johannesburg's water resource development and management, interwoven by colourful illustration and photographs. "Rather than addressing every little detail, the Johannesburg project was used to emphasise water imports to a city on a watershed, as well as the impacts of urban development on water quality," notes Dr Dippenaar.

For Johannesburg, it was important to decide between the wide range of topics, such as springs and wetlands, mining impacts, water supply, water

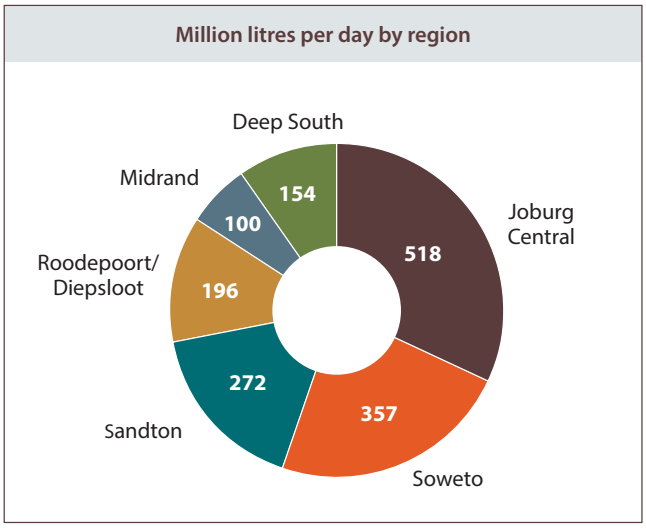
quality, water treatment and so forth. "While the Pretoria publication centred around the topics of groundwater and springs, the Johannesburg publication focused on its sophisticated water supply – taking water from as far as Lesotho – and how we as a community can work together to protect this resource. The most important theme addressed in the book is related to sustainability, with the compromise between environment and economy being determined by the need for improving society. Society therefore needs to become involved in order to better balance environment and economy for the future protection of water."

"Johannesburg is… a city with highly-skilled scientists and engineers who have done an excellent job in supplying the city's residents with high-quality drinking water."

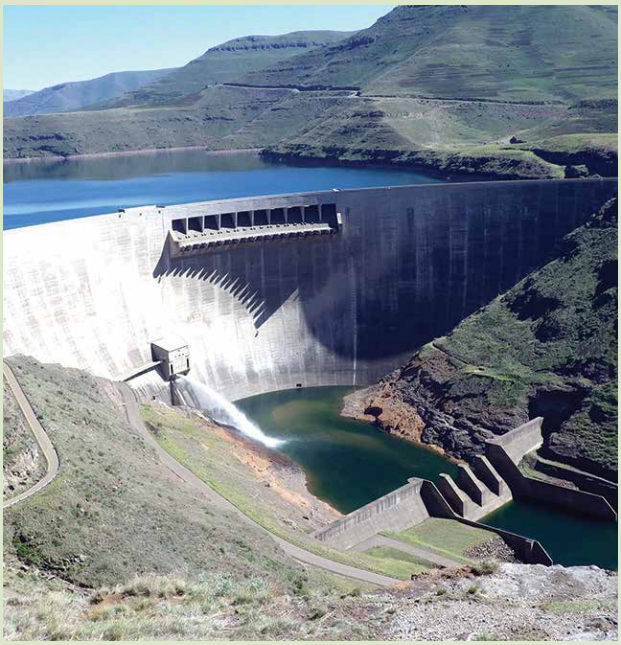
Dr Dippenaar has much praise for Johannesburg City municipality and their inputs into the project. The municipality made available all the required data and historical records, and accompanied the research team on a number of site visits. "The municipality and, particularly Nomvula Mofokeng of the Environment and Infrastructure Services Department, were extremely helpful. It was truly wonderful to work with a municipality who had bought into the project and immediately saw the value thereof."

An important message emanating from the publication – and the Hydrological Heritage Overview Series in general – is that there is a fine line between water as a basic human right and water as a seemingly abundant resource to be used excessively as a luxury, says Dr Dippenaar. "I hope the message will spread that water is not free, and that water supply is, in fact, a costly exercise. People should see water reticulated to their taps as proof that South Africa's skills in science and engineering are world class, and that our tap water is generally supplied at exceptional qualities."

A video has been developed to accompany the book. To view it, click on https://www.youtube.com/watch?v=2YqkmbpWyqs



The water demand of Johannesburg's different regions.



Johannesburg water resource development in a nutshell

Johannesburg was not always the economic powerhouse it is today. Founded around 1886, it started out as a dusty mining town, far from any major water source. People were initially dependent on small rivers and groundwater resources, with the first bulk water storage infrastructure – the Vaal Barrage – only being completed in 1923. This was followed by the Vaal Dam in the 1930s. When the Vaal Dam reached its water-supply limits in the 1970s, the South African government constructed the Thukela-Vaal scheme to transfer water from KwaZulu-Natal to Johannesburg. In 1986, the first water treaty signed between South Africa and Lesotho paved the way for the construction of the first phase of the Lesotho Highlands Water Project, one of the most ambitious water engineering projects ever to be undertaken in Africa. Through this infrastructure water is imported from the Senqu/Orange River in Lesotho to the Vaal River system in Gauteng. Planning for phase 2 of this project is currently underway to meet the growing water needs of South Africa.

Urban water

World's cities increasingly water insecure new study shows

With more than half of humanity now living in urban areas, the world's cities are facing unprecedented challenges in securing water supplies. This is according to a new report by the Nature Conservancy in partnership with the C40 Cities Climate Leadership Group and the International Water Association.

All cities, regardless of size, need a clean, consistent water supply to thrive, so it is little wonder that capital expenditures on water supply are large – US$90-billion a year – and growing. Unfortunately, drinking sources are increasingly insecure.

According to the report, *Urban water footprint – Mapping conservation solutions to the global water challenge* – cities face twin challenges, namely water that is both scarce and polluted. "Rising demand has been allowed to grow unchecked, competing users upstream do not talk to or trust one another, increasingly unpredictable rainfall patterns have been altered by climate change; and the watersheds where our water comes from have been degraded," the authors write in the report.

The report lays out a basic set of facts and ideas about the market potential for conservation to improve the supply of water, in particular its quality (what is now commonly known as investing in ecological infrastructure). The findings provide an important basis for comparing engineered and natural solutions and exploring how the two can be integrated to provide a more robust system.

With urban demand on the rise and catchments and their water quality increasingly degraded, cities are looking farther and farther from their boundaries for water (think about Gauteng receiving its water from Lesotho, for example).

It is estimated that the hundred largest cities in the world currently transfer 3.2 million m^3 of water a distance of 5 700 km every day in artificial channels. That means roughly 43% of water supply is obtained by interbasin transfer or moving one water from one river catchment to another.

According to the report, this is not sustainable in the long term. "[Moving more water ever great distances to meet demand] may also not be climate adaptive – even when taking into account inter-basin transfers, one in four large cities are already facing water stress today – and it will likely to be unaffordable to many cities, especially those in developing countries."

A different approach is possible: using the lands that source our waters more wisely. Investing in nature can change how land use in source catchments affects water quality and, over time, possibly water quantity.

Watersheds as natural infrastructure

To help determine where watershed conservation can help secure water for cities, the authors estimated the effectiveness of give common conservation strategies: land protection, reforestation, riparian restoration, agricultural best practices and forest fuel reduction. For each strategy, they evaluated how effectively it reduces sedimentation and nutrient pollution in more than 2 000 catchments that serve 500 cities.

The analysis finds that conservation strategies could measurably improve the quality of water sources serving over 700 million people living in the 100 largest cities. What's more, at least one of the five conservation strategies could achieve a significant reduction in sediment or nutrient pollution in the vast majority of the world's urban source catchments.

Water quality benefits can be achieved by targeting conservation on a small fraction of the area in source catchments. For example, implementing agricultural best practices on just 0.2% of the area where large cities get their water could reduce sediment pollution by 10%.

The findings suggest that the greatest potential to secure water for cities lies in improving the management of agricultural lands. This is especially true for sediment reduction, where over 600 million city dwellers would see a material improvement in the quality of their water sources if agricultural best management practices were applied in a targeted way to some 6.4 million ha.

Forest protection would benefit the second greatest number of people, about 430 million. However, to achieve the same impact on water quality as agricultural best management practices, this strategy would require conserving an area of land six times greater, some 41 million ha. The same trend is true of riparian restoration, suggesting that the additional benefits of forests, from recreation to carbon sequestration, would need to be monetised in order to fund source catchment conservation at a global scale.

Cape Town – Protecting land, reducing erosion

Cape Town is one of the cities featured in the report, *Urban water footprint – Mapping conservation solutions to the global water challenge*. Unlike many other cities, South Africa's Mother City sits amid one of the most biologically diverse areas on Earth, namely the Cape Floristic Region, which means, much of the water-source catchments around it are formally protected.

This means that, unlike many cities, Cape Town does not need to invest heavily in buying and setting aside protected areas. It does, however, need to ensure that the water sources areas stay healthy.

One of the biggest threats are invasive plants, such as pine, acacia, eucalyptus and others. These alien invasive plants take up enormous volumes of water, reducing the flow into streams and reservoirs. The problem is most severe in the region around Cape Town, where invasive alien plants have reduced the annual runoff by nearly a third.

One solution that is described in the report is the *Working for Water programme* that addresses both poverty and water scarcity while maintaining the ecological integrity of the landscapes. The programme, which employs around 32 000 people, has been active since 1995. In partnership with this programme, the City of Cape Town controls invasive plants in the water source area of the Wemmershoek Dam, one of the city's main dams as well as in the Peninsula watershed. The city also controls aquatic weeds on its various rivers to improve the health of the freshwater ecosystems.

Cape Town has relatively few options for increasing its water supply. Desalination plants and massive infrastructure projects to bring water from wetter areas of the country thousands of kilometres away are not economically viable and would take years, if they were possible at all.

The report concludes that the city will need to be more efficient in the way it uses water, and wise in the way it manages the catchments that provide it. In this case, removing thirsty alien tree species and restoring indigenous vegetation is critical to safeguard water services.

The authors admit that not all catchment conservation is equally cost-effective. "The amount of land on which conservation activity would have to be conducted to achieve a measurable reduction in a pollutant varies widely among cities. Effectiveness is greatest for small source catchments, were action on a relatively small number of hectares can significantly change concentrations of pollutants."

Using information on reported water treatment plant operations and maintenance costs from a sample of cities, the report shows that reductions in sediment and nutrients lead to significant reductions in treatment plant operations and maintenance. A reduction in sediment and nutrients by 10% leads to a roughly 5% reduction in treatment costs. If all possible conservation strategies were applied, global water savings on treatment plant operations and maintenance would be US$890-million a year.

Source catchment conservation saves money for utilities in other ways as well. For instance, investing in conservation strategies is likely to reduce capital expenditures over time for utilities, as cities can continue using cheaper water treatment technologies rather than upgrading to more complex, expensive technologies. Catchment conservation also creates value to cities beyond water treatment, including recreation, economic development and biodiversity.

The report concludes by saying that cities are drivers of stewardship for hundreds of kilometres around them. "They shape the landscape, and in doing so end up defining a route of development for both themselves and their neighbours in rural areas. Water managers should extend their definition of water infrastructure to include the entire river systems and watersheds that their cities depend on, and incorporate investment in those watersheds as part of their normal toolkit of securing water for people."

Securing adequate, clean water supply for cities is a global challenge that will require investment in both engineered and natural solutions. Cities that embrace both these approaches will not only meet future water demand; they will reshape the planet's landscape for the better.

To find out more, 'download the report at http://water.nature.org/waterblueprint

Table 1: Five conservation strategies to help secure water for cities

Strategy	Description
Forest production	Purchase of easements, land rental, fencing out cattle, and funding for park guards to maintain catchment services
Reforestation	Restoration of planning of indigenous trees, grasses and shrubs in critical areas to reduce erosion and related sediment transport
Agricultural best management practices	Implementation of cover crops, contour farming to prevent – and wetland and terrace construction to trap – sediment and nutrient runoff
Riparian restoration	River bank restoration and protection to reduce erosion and improve water quality
Forest fuel reduction	Conducting controlled burns and/or mechanical treatment to reduce wildlife severity and related sediment and ash pollution

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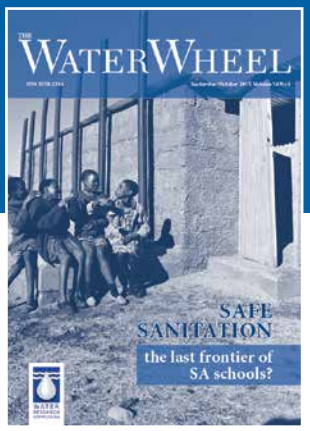

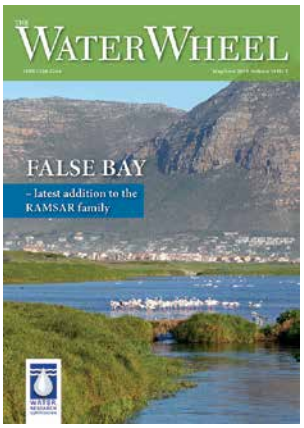

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Water KIDZ

South Africa's water bodies are home to many wonderful animals, including frogs.

South Africa's waterbodies play home to a whole host of animals and plants, one of the most fascinating being frogs.

There are more than 7 000 species of frogs in the world.

Frogs are part of the family of animals known as amphibians. Aphibians are cold-blooded animals that spend part of their lives in water and part of their lives on land. Amphibians were among the first vertebrates (animals with backbones) to inhabit the Earth. They are the only vertebrates that go through metamorphosis, in other words, from tadpoles that breathe in water through gills to adults that have lungs which survive out of the water.

Frogs have adapted to habitats ranging from mountain tops to sea level and from forests to deserts, and some live entirely on land, while others prefer the water. South African frogs belong to 10 families, and 50% of the 115 or so species occur nowhere else but here.

One of the most interesting things about frogs is their call. Each species has its own distinctive mating call which the males use to attract females to breeding sites, and as frogs are generally more often heard than seen, this is a useful way of identifying species. Seeing a frog calling is quite an amazing sight. Their sub gular flap (that is the elastic membrane underneath their jaw), expands and vibrates, giving off surprisingly loud noise for such a small animal.

According to Nick Evans from the Endangered Wildlife Trust, frogs also make distress calls if they are being harassed or attacked. This is in the hope that the predator will get a fright and leave the frog alone. It may also warn other frogs of the danger.

You may have noticed how a large cacophony of frogs will fall silent in an instant; this is an anti-predatory response, usually elicited in response to detection of movement through vibrations, explains Nick. What a good security system to have at home – you know if the frogs shut up suddenly, something, or someone, may be afoot!

Besides being really beautiful and interesting, frogs are a very important part of nature. They act as both a predator (of insects) and prey (for birds, fish, reptiles and other animals). Frogs also play an important role in pest control by eating huge numbers of pesky insects such as mosquitoes, flies and tics.

For scientists, frogs are bio-indicators, which means that their presence indicates a healthy environment. This is due to their semi-aquatic lifecycles and the fact that their semi-permeable skin make them particularly vulnerable to pollutants and other environmental stresses.

Unfortunately, all is not well with our frogs at all. As people pollute and destroy their homes, spread alien species and overhunt them for food and medicine, frogs are among the

most threatened animals on the planet. In South Africa, around 30% of frog species are Red Listed. This means they are threatened with extinction.

Frogs are quite harmless. Each species has its own distinctive sound and most frogs are active in the cooler hours of the night or dusk when the air moisture content is greatest, and insects such as moths and cockroaches are active.

Plant a frog-friendly garden

One of the best ways to help frogs survive is by planting a frog-friendly garden. You can start by installing a pond planted with marginal, floating and submerged aquatic plants. This will help attract frogs from all the different families. The flowers from these plants will also attract pollinating insects for the frogs to eat.

Remember to provide hiding places. Frogs, and especially toads, need a sheltered place to hide during the heat of the day, and also a place for hibernation during the dry season. Suitable shelters are beneath stones, in tree stumps or under logs. Rockeries are ideal for frogs.

Dense shrubbery is quite appropriate for frogs. In subtropical parts of the country, any dense, tallish planting will attract tree frogs. An outside light will attracts insects, and toads will follow. In addition, by turning on the sprinkler for a few minutes just before dusk during the summer evenings you will make your garden attractive to frogs. Avoid spraying your garden with toxic chemical pesticides and herbicides.

Having frogs call in the garden is one of the many privileges we have living in Africa. It is so much better than the sound of traffic or blaring music coming from a house party! So sit back, relax, and enjoy nature's music instead.

Froggie feasts

Frog festival, Chrissiesmeer
The Chrissiesmeer wetlands, in Mpumalanga, are home to 13 species of frogs. Once a year amphibian lovers hop to this town for a night of frogcatching for scientific research. To find out more, visit: www.chrissiesmeer.co.za

Leap Day for Frogs
In February each year the Endangered Wildlife Trust (EWT) hosts Leap Day for Frogs to celebrate and highlight the challenges of survival that frogs face in South Africa. Various activities are organised on this day. To find out more, visit: http://www.leapdayforfrogs.org.za/

Frogs are part of the amphibian family of animals that spend part of their lifecycle in water.

Facts about frogs

- There are over 7 000 known amphibian species in the world, of which 6 277 are frogs (the other being salamanders and caecilians)
- Not all frogs have tadpoles. There are many terrestrial frog species that emerge as froglets directly from the egg, bypassing the tadpole stage altogether. For example, the Bush Squeaker, which is found in KwaZulu-Natal.
- Most adult frogs have lungs like humans. However, amphibians have permeable skin that allows them to absorb water and oxygen directly from the environment.
- South Africa's smallest frog is also one of its most threatened. The Micro Frog, which only grows up to a length of 18 mm, only occurs in four localities in the southwestern Cape.
- South Africa's largest species, the Giant Bullfrog, can reach 25 cm and weighs in at 1.4 kg. Up to 80% of this species' habitat has been lost in urban areas, particularly Gauteng.
- A person that studies amphibians is called a batrachologist.

Source: EWT

A Tremolo Sand frog (Tomoterna cryptotis).

Annual dams conference bring generations of engineers together

This year's conference of the South African National Committee on Large Dams (SANCOLD), held in Cape Town in September, not only celebrated the organisation's 50th anniversary, but showcased the skill and expertise of a new generation of dam engineers. More than 200 delegates representing 13 countries attended this year's conference. In a special keynote address, Honorary President of the International Commission on Large Dams (ICOLD), Dr Theo van Robbroeck, took delegates through his remarkable journey in water engineering in South Africa. This was followed by several interesting papers under the theme, 'Dam safety, maintenance and rehabilitation'. This year, 23 out of the 47 papers presented were by young engineers (i.e. under 35 years old). This remarkable group of young people, many under the mentorship of the Department of Water and Sanitation, showed that South Africa's water resources are in good hands. "SANCOLD is extremely pleased that the contributions from young engineers into the organisation is growing," noted President, Danie Badenhorst. This growth is certainly attributed to the Young Engineers Forum, which was established in 2011. SANCOLD is currently preparing for the 2016 Annual ICOLD meeting and symposium, which will take place in South Africa in May. This is the first time this gathering of world water engineering experts will take place in South Africa since 1994.

ICOLD Honorary President, Dr Theo van Robbroeck, regaled the audience with his keynote address of his remarkable career as a water engineer in South Africa. Dr van Robbroeck played a major role in many of South Africa's most remarkable water schemes, among others, the Tugela-Vaal transfer scheme and the Lesotho Highlands Development Project.

SANCOLD President, Danie Badenhorst, opened the conference.

A number of young engineers presented papers at the conference.

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The Water Reasearch Commission not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting South African communities, reducing inequality and growing our economy while safeguarding our natural resources. The WRC supports sustainable development through research funding, knowledge creation and dissemination.

The knowledge generated by the by the WRC generates new products and services for economic development, it informs policy and decision making, it provides sustainable development solutions, it contributes to transformation and redress, it empowers communities and it leads various dialogues in the water and science sectors.

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