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BEING A NEW PARENT is a rude awakening. Being a new parent for the second time around leaves one feeling like a stream in a Karoo drought. As new fathers, Jason, a mate of mine, and I high-tailed it one evening to a local hang-out den for rain. After several minutes of preferred silence, and sipping gummy berry juice, we both observed that, of the 150 or so patrons, most were Mandela’s children dressed to the nines – middle upper-class young professionals. Even to the untrained eye, ours was the solitary conspicuous multicultural table. Jason is of European descent. Every other table comprised single race groups – there were several Black tables, White tables, and a Coloured table, spiced with a few Indian tables.

Upon raising this observation with colleagues the next day, some articulated that there really wasn’t a problem or cause for concern, purporting that people hang out with whom they feel comfortable. We tend to conglomerate with our own because we share common culture – cuisine, fashion, behaviour, interests, and that sort of rationale. While this might be true it perpetuates that undesirable status quo left over by a regime we all found deplorable. Verwoerd called it “… good neighbourliness …” For a modern South Africa that is not yet a normal society, I call it a load of garbage – self-imposed social apartheid, enforced by monopolies of the mind, obstinacy of will and a lack of trying, irrespective of how comfortable and warm it feels.

To change behaviour we need deliberate personal and external interventions. To improve relations with his children, with a view to a stable and wholesome family for example, a work-obsessed father needs to surrender to deliberate disruptive change in his behaviour by, say, rising earlier to have breakfast with his family, and leaving the office earlier in order to play with his children. In like manner, we need to make concerted, interruptive interventions to transform our work environment if we wish to accomplish the rainbow nation which I thought we all subscribed to. The default, comfortable, non-intrusive, do-nothing approach and letting it happen organically is just not working. Sweeping perceptions, innuendo, and involuntary discrimination under the carpet is no longer an option.

Our industry will only transform when we transform as individuals. How about observing the social environment in our businesses. Next time the office has a social, notice how your staff interact – is there integration or cliqued conglomeration of the safe and warm kind, by racial distinction? Observe also how corridor discussions unfold, how projects are allocated, and how mentoring and coaching roll out. How about making a deliberate effort to assess personal social circles – is there diversity and multiculturalism in your circle of friends, or does that rationale that you hang out with whom you feel comfortable, still pervade?

If we really want an integrated and equal society we need deliberate disruptive change that disturbs the status quo. When there is a single race group socialising at the office for example, consider invading the discussion and immersing yourself in the conversation. This will be sure to break the status quo and take office gossip to another level. Consider also your personal circle of friends next time you have a braai at home. Short of hosting diversity workshops and inviting change, consider discussing this article amongst colleagues and share views with an open mind. Perhaps consider learning an African language – language is an incredible barrier breaker and are doors to a true rainbow nation. Best-selling author Jackson Brown said, “Never make fun of someone who speaks broken English. It means they know another language.” Every South African should be able to speak at least three of our official languages and sing the national anthem.

South Africa is the only country that has a national anthem with five different languages in it. Our anthem is a miraculous hybrid of Enoch Sontonga’s *Nkosi Sikelel’ iAfrica* and CJ Langenhoven’s *Die Stem*, like ebony and ivory side by side on a piano keyboard. Our anthem is a fervent hymn and prayer that moves heaven and earth within a few minutes. The fathers of the struggle exquisitely concealed the vision of that new nation between the lyrics – embracing and respecting of all race groups and cultures under the banner of a new South Africa.

The words and spirit of the national anthem need to jump out of the hymn sheet, out of the rugby stadium, and into our belief. For belief informs behaviour, and behaviour is formed by habit. That mission is with you.

Ons sal lewe, ons sal sterwe
ON THE COVER
The DWS contracted SSIS Pipeline Services (Pty) Ltd, who represents Pure Technologies Ltd in South Africa, to provide comprehensive inspection, risk assessment and engineering analysis services on the Rietspruit–Davel–Kriel pipeline. The successful completion of the project highlights the value of using cutting-edge technology for comprehensive and proactive pipeline condition assessment.

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BACKGROUND
The Usutu Water Scheme in the Mpumalanga Province of South Africa supplies raw water to various coal-fired power stations and towns. The DN1300 mm, pre-stressed concrete non-cylinder pipe (PCP) between the Rietspruit and Davel Reservoirs (36.5 km), and between the Davel and Kriel Reservoirs (54.4 km) was completed in the late 1970s and forms a strategic link in the scheme.

PROJECT SCOPE AND EXECUTION
The Department of Water and Sanitation (DWS) contracted SSIS Pipeline Services (Pty) Ltd, who represents Pure Technologies Ltd in South Africa, to provide comprehensive inspection, risk assessment and engineering analysis services, including the following:

- Pipe specification development and material testing
- SmartBall™ and Sahara™ leak and gas pocket detection survey
- PipeDiver™ electromagnetic survey
- Steady-state and transient hydraulic assessment
- Cathodic protection and soil corrosivity survey
- Flown LiDAR survey

Advanced risk assessment and engineering analysis for DWS on a strategic bulk water supply pipeline

Pipe specification development and material testing
Due to a lack of records regarding the pipe specifications and design, pipes that had been removed from the pipeline, and spare pipes provided by the DWS, were destructively evaluated to determine the design specifications and calibrate the electromagnetic signal to accurately detect wire breaks. Laboratory and in-field tests and measurements were completed on the individual pipe components (i.e. mortar coating, pre-stressing wire and concrete core) to determine the integrity of the materials and develop design drawings and specifications.

Leak detection survey
The SmartBall™ leak and gas pocket detection surveys covered the entire pipe length. Follow-up Sahara audio-video surveys were performed to gain a better understanding of the leak locations. A total of ten leaks were detected and accurately located.

PipeDiver™ electromagnetic survey
An electromagnetic (EM) inspection provides a non-destructive method of evaluating the existing condition of the pre-stressing wires. EM inspections collect a magnetic signature for each pipe section to identify anomalies that are produced by zones of wire break damage. This inspection method is the best available technology to quantify the number of wire breaks to determine the baseline condition of a pipeline.

PipeDiver™ is a revolutionary free-swimming inspection platform that can be used to inspect pressurised pipelines, including PCP. The modular tool is articulated and has collapsible fins allowing it to pass through sharp bends, diameter reductions and butterfly valves. PipeDiver™ is neutrally buoyant and is carried by the flow of water. It was inserted and extracted under depressurised conditions. The survey was, however, performed while the pipeline was operational. The entire 90 km of pipeline was inspected in three runs. PipeDiver™ offers a major advantage compared to earlier man-entry inspections that required extensive periods of shutdowns and non-supply.

The electromagnetic inspections found that the vast majority of pipes did not have any wire break damage (Figure 1).
Transient pressure monitoring and hydraulic monitoring
Field verification data was used to compile a calibrated hydraulic model that accurately mimed the steady state and transient behaviour of the pipelines. The analysis found that the DWS’s current standard operating procedures effectively control the flow, and prevent excessive pressure surges. The calibrated model was also used during the engineering analysis to determine the pressure in each PCP section.

Cathodic protection and soil corrosivity survey
Various surveys were performed to confirm the current status of the cathodic protection and monitoring system, and to determine the corrosivity of the environment around the pipeline. The findings were compared with other survey findings to identify possible inter-relationships.

Flown LiDAR
The flown LiDAR survey provided high-resolution aerial imagery that assisted in developing detailed aerial maps of the pipeline. The LiDAR survey provided an up-to-date overview assessment of the depth of cover over the pipeline and indicated that the DWS generally maintains the pipelines’ servitudes well.

Structural analysis and risk assessment
Pure Technologies completed three-dimensional, nonlinear finite element analysis (FEA) to quantify the structural ramifications of the broken pre-stressing wire wraps detected by the electromagnetic inspection. The FEA provided performance curves unique to each PCP class that evaluate the structural integrity of a PCP with a given number of broken pre-stressing wire wraps and internal pressure. These curves were used in conjunction with the electromagnetic inspection results during the risk assessment.

The DWS’s risk exposure to pipeline failure was evaluated on a pipe-by-pipe basis, and was defined as the product of the pipe’s Likelihood of Failure (LoF) rating and Consequence of Failure (CoF) rating. The LoF rating incorporates the inspection results and structural evaluation, and is representative of the condition of the pipe. The CoF rating quantifies the social, environmental, and financial ramifications of a pipe failure, and is representative of the total impact.
of a failure. The risk rating of each pipe barrel is used to guide proactive intervention and management.

**FINDINGS**

The inspection and condition assessment determined that the majority of both transmission mains are still in a reliable and manageable condition. However, some individual PCPs have a higher risk rating and need to be attended to. The distress in both transmission mains can, however, be economically and effectively managed with targeted remediation and an appropriate long-term management strategy. A number of specific intervention actions were recommended to the DWS.

This project highlights the value of implementing a comprehensive and proactive pipeline condition assessment programme using international best practice and expertise, and cutting-edge technology. The DWS originally faced an unknown and ill-defined risk, or even worse, full infrastructure replacement at significant capital cost based on pipe age, failure history and perceived risk as its only indicators. This investigation, however, confirmed that the asset life can be extended while managing the DWS’s exposure to risk. Further action will be required, but with the baseline set, the DWS can now implement a proactive approach to the management of this valuable asset, setting an example for other utilities faced with similar challenges in South Africa.

![Figure 1: Electromagnetic inspection findings](image_url)
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How can we, as South African civil engineering practitioners, improve flood management in South Africa?

FLOODS IN SOUTH AFRICA in the 2013/2014 rainy season caused at least 50 fatalities and affected about 50 000 people. In addition to loss of life and injuries, people were evacuated from their homes, and/or their homes were damaged or destroyed. An indication of the damage is depicted in the map below (based on articles on floodlist.com).

Although no major floods were reported for the rainy season (2014/2015), the flood damage impact in 2013/2014 was not exceptional. For example, in the rainy season of 2010/2011 there were 103 fatalities, with total damages estimated at approximately 1.1 billion USD (Zuma et al 2012).

The Disaster Management Act is not specific about floods, or any type of disaster. It is based on a subsidiarity principle, placing
responsibilities at the lowest level. It appears that a key assumption of the Act is that most flood preventive management is the responsibility of the municipalities, although the provinces and national disaster management centres will act once a disaster reaches a larger scale.

However, municipalities, provinces and national government seem to be quiet in terms of issuing flood damage prevention projects. Has South Africa forgotten the need for flood management already?

Of course, the overall flood hazard in South Africa is less than in lower-lying Mozambique. In the Zambezia Province alone, in January 2015, there were 117 fatalities, and an additional 157 000 people who were negatively affected (floodlist.com). Then, of course, local flooding is not comparable with conditions in certain other countries, such as the Netherlands, where protection measures are phenomenal, with a design flood frequency of 1 250 years for river floods and 10 000 years for sea storm surge protection. This approach makes socio-economic and technical sense in the Netherlands, but in South Africa it would not.

Resources in South Africa are scarce, the areas are large, and floods often arrive without warning, as in the case of flash flooding. As in our neighbouring countries, it is difficult to move people out of flood plains and keep them out.

So let us assume there is little money available for flood risk management. What can we do, as the civil engineers of South Africa, to play a pivotal role? We would like to offer a few suggestions.

LET US MAKE BETTER USE OF EXISTING FLOOD STUDIES

We can make flood line data more publicly available

South Africa actively prevents flood damage through flood mapping to restrict or manage development along rivers. This is a legal requirement – Water Act Sections 39 (updated in 2009) and 144, and the municipal acts – in procedures for dam safety, for town planning and for water use licence applications. These maps are filed in the Dam Safety Office of the Department of Water and Sanitation (DWS), in the Town Planning / Stormwater Management sections of all municipalities, and in the regional DWS offices, respectively. This information is probably available on request, and in some cases is available on the relevant municipal websites. Can we not reuse this information and put it in a central database at the Department of Water and Sanitation, or through the National Disaster Management Centre? It could be reused not only for planning, but also for emergency purposes, and could form part of the Integrated National Early Warning System which is currently in the making. Without necessarily making the data or maps themselves available, a link to the consultants who had done the job would already help. These consultants could even be asked to fill in that database, although there might be some complications, due to differences in the level of accuracy and assumptions made. Granted, not every event is a 1:100 year event, so the value for emergency actions would have to be evaluated, but it would at least be a start.

We can offer flood forecasting solutions

Such forecasting solutions can often be very cost-effective. Currently, the DWS only uses traditional flood routing (Muskingum) for flood forecasting in the Vaal–Orange River system, while the South African Weather Services are independently building a flash flood forecasting system. Mozambique is developing a flood forecasting system for the Limpopo River basin, which would also benefit from improved forecasts from South Africa. We should avoid redoing work, and start with existing data, models and information – this is possible in open data handling platforms developed for forecasting, such as Delft-FEWS. For example, in the Orange–Sengu River basin, we could perhaps start with the existing hydraulic models developed for different clients and for different purposes. Improved forecasting is also viable for urban flooding, where there are many tools available to improve real-time flood observation and forecasting, with different dashboards for different stakeholders.

We could undertake and communicate hydraulic analyses

We could undertake hydraulic analyses not only to determine flood inundation extents (flood lines), but also maximum flood depths, response times and/or velocities, to better understand which hazard we are talking about. We could also combine this hazard information with vulnerability and manageability. This information is key to making informed decisions in the planning processes of flood-prone regions. Both clients and consultants could benefit from this critical additional information. We will, however, need to work towards a more homogeneous approach to flood hazard, vulnerability and manageability rating, as there are no guidelines for such ratings yet that are directly relevant to the South African context.

LET US MAKE FLOOD THINKING PART OF OUR DESIGN THINKING

We could share lessons learnt with municipalities

As engineers involved in the design of stormwater management systems, we could contribute to knowledge sharing by informing our municipal clients (particularly at smaller municipalities) of the lessons learned at other municipalities, or elsewhere. For example, some South African municipalities have developed bylaws or guidelines specifying how stormwater must be managed on new development sites, both during and after construction. Good stormwater designs can improve not only flood management, but also landscapes and water resources management, working towards watersensitive urban designs.

We could improve the designs of facilities lying in flood plains

We could improve the designs of public facilities that unavoidably lie within the flood plains of large rivers, e.g. schools, clinics, etc. These facilities could be designed to be flood proof, and could even serve as refuge areas. During the 2013/2014 season two schools, with about 500 learners each, were flooded (Ganyesa and Mabel-a-Podi). We could learn from good examples built in our neighbouring country, Mozambique.

LET US IMPROVE COMMUNICATION BEFORE AND AFTER FLOODS

Between risk teams, water experts and emergency services

We could initiate and facilitate discussion forums between disaster risk management teams and hydrological/water
management experts, and the police and fire brigade. If this is not done before flooding occurs, then it still makes sense to evaluate floods, to see what has been learned and how communication can be improved, as communication is often an issue. Royal HaskoningDHV facilitated such a session for a metropolitan municipality, and discovered this was, surprisingly, not common procedure. Most people around the table had never met one another before. Simulation of a flood (on an arranged day) is a good way of improving operational flood disaster management by ‘playing’ the different organisations’ roles as if the flood were real. Cooperative government can only be really learned by applying the Plan-Do-Check-Improve circle many times, and then rather with a virtual flood than with a real one.

Better communication tools
We could assist in improving communication tools for awareness-raising, which can range from cell phone Apps to installing visible flood line markers.

Raising awareness among political leaders
We could raise awareness among political leaders regarding the costs of past flood events, and on what could be done to prevent such occurrences again in the future, to help them allocate appropriate funds.

CONCLUSION
These are all broad ideas, of which the feasibility would have to be further investigated for different regions. Our message is that South African civil engineering practitioners could be more inventive regarding how we use our limited resources to improve flood management in South Africa.

REFERENCE

As engineers involved in the design of stormwater management systems, we could contribute to knowledge sharing by informing our municipal clients (particularly at smaller municipalities) of the lessons learned at other municipalities, or elsewhere. For example, some South African municipalities have developed bylaws or guidelines specifying how stormwater must be managed on new development sites, both during and after construction. Good stormwater designs can improve not only flood management, but also landscapes and water resources management, working towards water-sensitive urban designs.
A wealth of new freely downloadable information on the water resources of South Africa, Swaziland and Lesotho

BACKGROUND

The National Water Resources Strategy (2013) states: “For water to play an optimal role in poverty eradication, the reduction of inequality, inclusive growth and development, and building a just and equitable society, water resources planning must be integrated into national, provincial and local planning, and must be addressed in all growth and development strategies.”

The WR2012, a ground-breaking water resources study, indeed provides a new and enhanced water resource analysis for South Africa, Lesotho and Swaziland. It is being funded by the Water Research Commission (WRC) and supported by the Department of Water and Sanitation (DWS).

Both authors, together with other key water resources experts, were tasked with developing the WR2012 study. Water resources appraisals have been the life work of both authors, who have collaborated in the building and enhancing of Professor Desmond Midgley and author Pitman’s original work, dating back to the 1950s.

The WR2012 study started in 2012 and is due for completion in April 2016. Instead of waiting until finalising the whole study, work done up to date is posted on the website www.waterresourceswr2012.co.za.

AIMS AND OBJECTIVES

The aim was to build on the previous water resource appraisal of South Africa, Lesotho and Swaziland, which was called WR2005, by using updated data and information, and new tools and technology. This would increase the knowledge on water resources for planning purposes, and would make the knowledge more accessible through a website (Figure 1).

PROJECT DESCRIPTION

The rainfall-runoff WRSM2000/Pitman model, named after its innovator and developer Dr Bill Pitman, is a key part of this project, and has undergone further enhancements during this (WR2012) study. Outputs from the Pitman model are used...
The rainfall-runoff WRSM 2000/Pitman model, named after its innovator and developer Dr Bill Pitman, is a key part of this project, and has undergone further enhancements during this (WR2012) study. Outputs from the Pitman model are used as the primary inputs to water resources planning models of the Department of Water and Sanitation. The WRSM 2000/Pitman model is also popular for application in other African countries.

This is the first appraisal in which the Pitman model was applied for the full time series since 1920 under present day water use conditions, to show what the runoff would have been if the land cover and water use had been for the whole period 1920–2010, as it is now. Comparing this with the naturalised flows, (the flows derived as if all catchments are still pris-
tine), gives an indication of the human influence on our river flows.

Figure 3 indicates that many catchments in the water management areas (WMA) have outflows that are on average considerably lower than they would have been under naturalised conditions.

The previous water resources appraisals have shown a decreasing trend in the total of the estimate of average naturalised mean annual runoff (MAR). The WR2012 study has come out about the same as the previous one (WR2005). Figure 4 shows the change in mean annual naturalised runoff since 1952 of all outflows to the ocean or to other countries combined.

PROBLEMS ENCOUNTERED AND INNOVATIONS

By far the biggest challenge was the deterioration of data in the form of rainfall, observed streamflow, reservoir records (dam balances), land cover/water use, water quality, etc. Rainfall is the most important and shows the biggest decline in terms of rainfall stations which have closed down. This deterioration of data makes it harder for hydrologists and water resources practitioners to enter data of the necessary quality into water resource models. These models produce hydrological information on streamflow, yields of dams, water quality trends, future demand versus supply trends, ecological water requirements, etc. Obviously the accuracy of the above information will become compromised should this very distressing situation continue.

Figure 5 indicates that the number of streamflow stations used in the appraisals since 1969 have increased with...
every appraisal. However, it is worrying that for the streamflow stations that were considered useful for the WR2012 study, already about 200 of the 600 have closed down. Their historical records were used, but no new data is becoming available.

Some innovative tools have been added to the WRS2000/Pitman model to help overcome these data problems, such as the ability to calibrate not only on streamflow but also storage in dams. This has been made of tools such as Google Earth to improve on the catchment detail.

To assist water resources professionals who do future studies, the flow gauging stations have been categorised as for their quality, and a database was maintained with remarks on the reason for putting them in a certain category. The gauging stations’ quality is indicated in maps, as shown in Figure 6.

CONCLUSION

With about 75% of the study complete, and virtually all of the core water resources analysis complete, the key information for water resource planners is already available on the website (see box on page 17). In the last year of the study, the website will be supplemented with further deliverables and enhancements.

It is expected that the WR2012 website with all the GIS maps, WRS2000/Pitman model with associated data sets, water quality models, reports, spread-
Already complete and available on the WR2012 website are the following:

- WRSM2000/Pitman model (monthly time step) including the latest data sets, network diagrams, etc, for South Africa, Lesotho and Swaziland.
- Rainfall – individual rainfall station patched data up to September 2010, catchment rainfall groups and catchment rainfall.
- Observed patched streamflow up to September 2010.
- Naturalised modelled streamflow from 1920 up to September 2010.
- Monitoring information on rainfall, observed streamflow and water quality with recommendations for improvement up to a minimum desired state.
- Natural and present day streamflow analysis per quaternary catchment.
- WRSM2000/Pitman data sets at present day levels of development are available. Natural and present day streamflow have also been summated and analysed on a water management area (WMA) basis.
- Land cover/water use spreadsheets with information on dams, abstractions and return flows, irrigation, alien vegetation and afforestation.
- Daily time step in WRSM2000/Pitman model for naturalised streamflow, as well as catchment analysis including land cover/water use.
- Water quality analysis of a number of water quality parameters per quaternary catchment.
- WRSM2000/Pitman model, the previous WR2005 study reports and a water quality report.
- WR2012 Sami groundwater report.
- All available reservoir records.

We recommend that all water professionals watch the website www.waterresourceswr2012.co.za over the coming year, as more deliverables will be added that are still being completed as follows:

- WR2012 Executive Summary and Users Guide.
- Map book of 77 GIS maps with background, rainfall and runoff maps for each water management area (WMA), and other relevant maps for South Africa, Lesotho and Swaziland. The previous WR2005 study GIS maps are currently on the website and are to be updated for WR2012. They are in hard copy and electronic format, and cover numerous water resources issues, such as rainfall, streamflow, evaporation, land cover, WRSM2000 calibration parameters,
geology, soils, sediment, vegetation, ecological water requirement management classes, water quality in terms of total dissolved solids (TDS) and population. The electronic maps are in ArcView with zoom, search and other standard tools.
- Statistical analysis of about 600 streamflow gauges and reports. This analysis was used to assign each streamflow station to one of six categories which have been shown on GIS maps as different colour dots.
- Enhanced WRSM2000/Pitman model with daily time step, and a number of improved graphics such as graphics enhancement, calibration on storage, multiple runoff module calibration, additional graphs on streamflow and rainfall, new irrigation methodology, etc.
- Quaternary data spreadsheets. The previous WR2005 spreadsheets are being updated with WR2012 data for catchment areas, rainfall, evaporation, naturalised streamflow, Pitman calibration parameters and Sami groundwater default data.
- Salinity modelling of the entire Vaal River, i.e. the entire new Vaal WMA, showing graphs and tabular information for TDS.

Training in the use of the models and the website data can be provided on request.

ACKNOWLEDGEMENTS
The Water Research Commission and support from the Department of Water and Sanitation are gratefully acknowledged, as well as support from other consultants who contributed in the reference group or through providing data – Dr Chris Herold, Karim Sami, Grant Nyland, Dr Marieke de Groen, Tobias Göbel, Kerry Grimmer, Saieshni Thantony, Sarah Collinge and Ansu Els.

With about 75% of the study complete, and virtually all of the core water resources analysis complete, the key information for water resource planners is already available on the website. In the last year of the study, the website will be supplemented with further deliverables and enhancements.
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The Emfuleni Lessons – how to deliver on water-loss reduction in a South African municipality

As a result of a collective effort from public and private entities, about 6.8 million m³ of water, and in the order of R37 million was saved in Emfuleni - one of South Africa’s largest local municipalities - by implementing a range of comprehensive water-loss reduction measures. This article outlines how this was possible and what needs to be considered when implementing similar approaches elsewhere.

INTRODUCTION

Municipalities in the Southern African Development Community (SADC) are faced with numerous resource constraints, including challenges in assuring stable water and energy supply to residents as per their legal mandate. This often occurs in conjunction with serious limitations in municipal budgets and a limited capacity to collect enough revenue from tariffs, resulting in continued shortcomings in infrastructure operation, maintenance and development, and often an aggravation of the aforementioned situation. Municipalities are in many instances not in a position to collect enough revenue from tariffs to replenish constrained municipal budgets for service delivery.

One of the key challenges encountered in the already water-scarce regions of southern Africa is water losses in municipal water supply systems due to pipe and plumbing leakages, as well as waste at the point of use. These losses quite frequently amount to 50% of the water produced, reflecting an overall global trend for the developing world, as recorded by the World Bank (World Bank Group 2006).

Such municipal water losses are highly problematic, as they pose an additional burden on already underfunded and strained municipal budgets, and compromise sustainable access to water for households, businesses and other water users. On a larger scale, municipal water losses considerably compromise the achievement of sustainable water resources management, and thus essentially one of the foundations for sustainable development, given increasing pressures due to population growth, economic development, urbanisation and possible climate change effects (GIZ 2011).

Most surprisingly, water-loss reduction does not feature high up on the municipal priority list. Rather, municipalities usually resort to identifying ‘new’ (and expensive) sources of water, which normally require major investments in new infrastructure.

The possibility of rather inexpensive or even cost-saving and yet highly effective measures to achieve water-loss reduction has thus spurred an interest in innovative approaches and related capacity-building measures to address municipal water losses. Emerging patterns include cooperative models with the private sector, as companies may themselves be affected in one way or the other by increasing water stress.

A comprehensive water-loss reduction project has been undertaken in the South African Emfuleni Local Municipality (ELM) through a joint effort by the municipality, South African integrated chemicals and energy company Sasol, ORASECOM (Orange–Senqu River Basin Commission) and GIZ’s Trans- boundary Water Management in SADC programme. It now represents a compelling example for successful collective action in tackling this key water management challenge, and also establishes best practice in creating multiple ancillary benefits (employment, trust, energy savings, recognition, etc) with a long-term perspective.

What were the key components of this project, how did the process unravel, what were major achievements, and what were challenges and success factors? This article offers insights into the setup, governance, financing and implementation of a project approach for tackling large-scale water losses, and provides lessons learnt to be taken into consideration for potential replication of such activities in South Africa and beyond.

PRO JECT SETUP

Key partners

Emfuleni Local Municipality, one of South Africa’s largest urbanised municipalities and home to more than 720 000 people, is situated south of Johannesburg and located in the Vaal catchment. The Vaal is a tributary to the transboundary Orange–Senqu
River, which supports roughly 60% of economic activities in South Africa’s economic powerhouse, the Gauteng Province. Like many municipalities across South Africa and Africa, Emfuleni was facing the challenge of having non-revenue water of close to 50% (DWA 2007). This water is purchased from the bulk water supplier Rand Water and sourced from the Vaal River system.

At the same time the municipality was confronted with a savings target set by the South African government of about 15% water loss reduction. Residents in the municipality were largely unaware of this problem and did not engage in water conservation. In addition, the municipal budget did not allow for initiating large-scale efforts targeted at water conservation measures.
Sasol is a South African-based oil and gas company with 34,000 employees worldwide and revenues in the order of 21 billion USD annually (Bloomberg 2015). Its main production sites – Secunda and Sasolburg (the latter in the vicinity of Emfuleni) – have a combined water use representing 4% of the Vaal River yield. As a major water user, Sasol maintains a vital interest in improving water security in the Vaal basin, and is continually striving to improve efficiency at its operations. While considerable amounts had already been invested in water-use optimisation, assisting neighbouring Emfuleni in water-loss reduction measures offered an additional and cost-efficient way of investing in water security. Sasol considered its involvement as a pilot approach for further application elsewhere. In addition, the company was hoping to kick-start an offsetting process by which access to water would be more secure in return for supporting sustainable water use by reducing municipal water losses (GIZ 2012).

ORASECOM, the Orange–Senqu River Basin Commission, representing the interests of all riparian countries in the Orange–Senqu River basin, was interested in testing and promoting new approaches towards addressing key water management challenges encountered in the transboundary basin through effectively involving the private sector and building on the existing need for increased water security.

Finally, GIZ’s Transboundary Water Management in SADC Programme (GIZ-TWM) is a regional water programme of the German Development Cooperation. The programme is supporting the SADC Water Division in the implementation of innovative water-related projects, and also cooperates with several river basin organisations across southern Africa. A focus area of this intervention was to explore the potential of development partnership projects (DPP) as a key element in addressing water-related challenges occurring in shared basins, and to ensure the uptake of lessons learnt for further replication in South Africa and other SADC member states.

Project governance
Arrangements between project partners were based on two main agreements. Firstly, Sasol and GIZ entered into a development partnership project (DPP), a partnership vehicle supported by the German International Cooperation allowing for cooperative arrangements with private sector entities. As a second step, the Sasol/GIZ partnership entered into a Memorandum of Understanding (MoU) with the Emfuleni Local Municipality (Figure 1). This MoU specifies the obligations of all parties, including financial commitments and the governance structure of the project, consisting of three key elements:
- A project steering committee, providing strategic direction for the project
- A community stakeholder committee, managing community engagement issues
- A project management committee, dealing with the day-to-day management of the project.

Project financing
Sasol and GIZ made available the seed funding (R5 million each plus additional in-kind contributions), which kick-started project activities. A managing consultant was contracted through a joint tender by GIZ and Sasol to assist the municipality in achieving initial water, and thus financial, savings. These savings were to be ring-fenced and reinvested into further water conservation measures by the municipality.
Over the course of the project, the Emfuleni Municipality reinvested about R16.5 million from the savings back into the project – amounting to an overall investment of R26.5 million. As depicted in Figure 2, the combined GIZ and Sasol funding were used up by May 2013 – the further continuation was solely carried by the municipality’s own funds. The break-even point, i.e. cumulated water savings exceeding costs, was reached about one and a half years after project start.

Results
Project activities commenced in April 2012, and two years later the following results could be reported:

The identified project area consisted of 106 092 households with a population of 368 034. Based on historical usage and growth data, the estimated water demand for the two financial years from July 2012 to June 2014 was 82 million m³ which was reduced to 75 million m³ – a saving of 6.8 million m³. In terms of the tariffs payable to Rand Water, this represented savings of R37 million for the municipality.

In the following sections we outline which concrete measures were taken within the scope of the project, and also what other benefits could be achieved.

MEASURES UNDERTAKEN
Essentially, measures can be grouped into two main categories, which are intrinsically linked to each other:

■ The provision of education and awareness-raising services for the community in water conservation and hygiene issues, offered by specially trained community members (the so-called Water Conservation Warriors), as well as awareness-raising and training for councillors and key staff at the Emfuleni Municipality.

■ The reduction of physical water losses in prioritised areas through pressure management, and repair of leakages in the supply network and in household water installations, using locally recruited and specially trained plumbing task teams.

Awareness and education
Unemployed young people from wards in the project area were appointed as Community Liaison Officers (they called
themselves Water Conservation Warriors) and were equipped and trained in water conservation matters. Over the course of the project they visited some 103 000 households, having conversations with house owners and tenants, and gaining access to 59 000 houses, while leaving leaflets at the properties where they could not speak to the residents. They also reported leaks at 42% of the households accessed, directly prompting the plumbing teams to address the reported problems. The Water Conservation Warriors conducted regular awareness workshops and discussions at various clinics, shopping centres, schools and community-based organisations – more than 370 events attended by approximately 36 000 people. The Water Conservation Warriors also participated in various municipal events throughout the period, including Water Week, Youth Day, etc, where water conservation and demand management principles were promoted. Accredited training was also given to:
- Councillors on the principles of water management and conservation
- Previously unemployed persons (male and female) from the project area on the basic skills of plumbing, who were then employed to assist the qualified plumbers
- Caretakers at schools to assist with leak repairs at these schools.

**Domestic leakage repair**

Massive water losses were incurred due to leaking taps and toilets at household level. This could be directly related to an existing culture of non-payment of water bills in the project area. There was therefore only limited awareness among the residents regarding the importance of reducing water use, fixing leakages in their homes or reporting leakages in the network. The purpose of this part of the project was to make residents aware of water losses and the accompanying negative impacts, while at the same time demonstrating to them the ease with which simple repairs could be carried out by just about anybody.

Three local plumbing companies were selected to undertake the household leakage repair work and also train further community members as assistant plumbers. Plumbing tasks comprised the identification and repair of basic leaks in the domestic water supply system. Typically this involved a simple replacement of washers for a tap or toilet cistern, but could also involve a replacement tap (plastic to reduce the chance of further loss or theft) or cistern fittings. In the first instance, the purpose of the exercise was to fix the existing leaks, but secondly and mainly to capacitate house owners and tenants to carry out such simple repairs on their own in the future. During this process the plumbers would also identify and, where possible, fix leaking service pipes or meters.

The cost of the plumbing teams averaged out to around R120 for each house where a repair was carried out. As a typical household with a leak or wasteful use could consume up to 200 m³ of water (cost equivalent: R1 000) in one month, this proved to be a cost-effective intervention.

The plumbing teams covered about 91 000 households where they replaced 61 000 tap washers, 73 000 toilet inlet washers and 71 000 toilet outlet washers, in addition to repairs made to internal plumbing systems at 70 schools.

**Repairs to the municipal reticulation network**

The original focus of the project was to only undertake repairs at household level, i.e. after the meter or main supply point. It soon
became clear, however, that it would also be beneficial to assist municipal staff with attending to leaks in the municipal water supply system. This involved undertaking some repairs directly, but also sourcing specialist equipment and fittings where these were not readily available through the municipality. The awareness component of the project also created an increased level of complaints about leaks to the municipality. It was found that other contractors in the area were damaging supply pipes and, rather than reporting the damage, concealing the fact by channeling the water to sewers or stormwater systems, creating high levels of water loss. With the approval of the municipality, this problem was also included in the scope of the project.

Pressure management and pressure zone optimisation
The application of pressure management is considered an advanced practice which has significant impacts in terms of reducing water losses due to leakages – this is particularly evident across southern Africa where pressures applied in the water supply networks are often higher than necessary. Due to prior work undertaken on pressure management in the project areas, additional measures could be quickly identified and remedial action taken. Most zones were controlled by pressure-reducing valves, but often the settings had been changed and not reset due to the need to address intermittent water shortages in different areas. Linked with this was the need to identify situations where maintenance work had left critical valves for the integrity of pressure and supply zones open or closed. An important tool in this work was the existing telemetry system which allowed for the continued monitoring of the supply flows and pressures at critical points in the system.

ADDITIONAL PROJECT ACHIEVEMENTS

Job creation
In addition to the mentioned water and financial savings, the project had significant positive employment effects in the selected wards. Over 90 local people were employed during the project period, including 25 Water Conservation Warriors and 59 plumbers and plumbers’ assistants. The gender mix of local employment was in the order of 50/50 and contributed significantly to the acceptance and success of the project. Training ensured that skills were developed and capacity built up for the long-term.

Environmental quality and integrity
The reduction of leakages also had a positive effect on the amount of drinking water flowing into the sewer system. This entails further benefits for the municipality, as well as the entire catchment. The resultant load reduction of an already overloaded sewage treatment works will help to improve the efficiency of the treatment process, as well as reducing spillages of wastewater into streets and streams, thereby also improving the hygienic situation in the affected areas.

Furthermore, reducing water wastage helps avoid, or at least delay, the construction of costly infrastructure projects such as dams, (waste)water treatment plants and transfer pipelines, thus allowing for limited (municipal) financial resources to be applied where needed the most. At the same time the measures help to ensure that the limited (water) resources available can be supplied to the maximum number of users.

In the transboundary context one needs to consider that measures supporting water saving help to relieve stress in already water-constrained basins, and thus satisfy demands of households, industries and agriculture. Eventually this will be a crucial element in avoiding potential conflicts among these different user groups, and in some cases also between riparian countries in shared river basins.

Energy savings/Climate impact
Further benefits include considerable energy savings incurred due to reduced need for pumping water into the municipal supply system (these costs are incurred/saved by the bulk water provider Rand Water). Given South Africa’s strained energy situation, any reduction in energy consumption must be considered a key priority. In addition, energy saved is directly linked to reduced CO₂ emissions (in this case in the order of 10 260 tons) (WRP Consultants 2014), alleviating the severity of climate change impacts.

Overall, this contributes to massive savings in water and energy – two crucial drivers for economic development, which, if saved, can be put to more productive uses and improving livelihoods for all.

INDIRECT BENEFITS
The overall success of the project becomes even more noticeable if one considers other, indirect benefits for the partners:

Trust building
The intensive outreach to and involvement of the community leads to tangible benefits which were visible through jobs created and awareness-raising campaigns conducted. Further benefits in terms of improving people’s livelihoods range from a more reliable access to water and sanitation, via a heightened overall awareness for water conservation, to improvements in social cohesion and neighborhood relations. Add to this an increased ownership of the community’s own situation, a feeling of overall security, as well as a heightened trust in authorities. The awareness and education component of the project also assisted the municipality to develop better relations with its customers, thus helping to improve service delivery and showing an improved responsiveness for customer queries.

Reputational gains
The municipality, as well as Sasol, ORASECOM and GIZ, have enjoyed reputational gains from positive public perception and media reports. The project received a number of prestigious awards in the water sector, including the Mail and Guardian Greening the Future Award 2013 (Category: Water Management Award), given to Sasol’s Water Sense programme, and the South African Department of Water Affairs’ Water Sector Awards on Water Conservation and Water Demand 2013. In 2014 the project received a distinction in the Corporate Water Stewardship category at the Global Water Awards.

For Sasol, it was furthermore crucial to build trust with government partners at various levels, and the considerable recognition gained with political leaders through this project is not to be underestimated. The former South African Water Minister, for example, has referred to the Emfuleni Project as a best case in point, and officially endorsed future replication.

Given the heightened interest in water-loss reduction within South African municipalities and the launch of the No Drop Programme, new projects with a similar setup become more and
more likely. In designing replication projects, one can draw on a number of lessons learnt captured from the Emfuleni experience.

LESSONS LEARNT
In the first place numerous lessons were related to practical challenges (technical, social and financial aspects) encountered during project implementation. Furthermore this article discusses best practice in terms of project governance and political backing for water loss reduction measures.

Technical aspects
Project success is crucially dependent on establishing a verifiable and credible baseline of water consumption in order to assess the extent of the water savings. In this case, historic data, as measured by the bulk water provider (Rand Water), were used to extrapolate an agreed baseline over the duration of the project period. The baseline for the project area indicated a 4% annual growth in water consumption under a ‘business-as-usual’ scenario. Next to establishing the baseline, communicating and explaining its relevance to councillors and municipal officials is one of the key tasks in order to assure the acceptance of savings achieved during project implementation. Senior financial officials should always be an integral part of the project team to help approve the project achievements in terms of cost savings and to facilitate the reinvestment in further water conservation measures.

The establishment of an agreed baseline will, however, be more difficult where an entity treats and supplies its own water, and where historic records from proper bulk metering are incomplete or not available.

In order to assess actual savings, regular measurements of actual water consumption are conducted at agreed measuring points. Irregularities in these readings are, however, inevitable. At Emfuleni these resulted from:

- varying meter-reading intervals (ranging between 27 and 32 days)
- construction works in the water supply system (installation of a new reservoir)
- replacement of bulk meters by Rand Water.

All of these can impact on the quality of measurement.

Independent check meters at crucial supply or demand points can help to mitigate this problem. Reading irregularities are bound to occur due to the complexity of a water supply system. An upfront agreement among project partners on how to manage these should be in place.

Regularly undertaken valve and meter audits are a viable tool for assuring the quality of the measurements, as well as adequate pressure distribution in the entire reticulation system.

Social aspects

Awareness and community outreach
Community engagement through awareness and education components was a key element of this programme, and should always be given high priority. The identification and appointment of the Water Conservation Warriors was a rather sensitive task and needed to be carried out with certain care and consideration to ensure appropriate representation within the respective wards. Although appointed as one for each ward they generally worked in groups of two or more for security reasons. The balanced mix
between male and female was also beneficial, as females were generally more accepted in some environments, while the males fitted into others. The high female representation, for example, helped gain access to those households where mainly female inhabitants were present during working hours. Once a week the Water Conservation Warriors came together as a group and visited schools or some form of community gathering to promote the need to respect and save water.

Various forms of media were used to support the programme, including picture-based pamphlets printed in the local languages. It was the opinion of the team, however, that the most successful form of media was the local radio stations, and that this avenue is particularly recommendable for future projects.

In addition to the work and impact of the Water Conservation Warriors, the support of the senior councillors responsible for water services, and of the local ward councillors, was critical in ensuring communities’ support and participation. These councillors were given short courses on water management and were involved in the identification of candidates for the various employment opportunities. They were also asked to assist in maintaining the project momentum through ensuring that water conservation remains a standing item on their local meeting agendas.

Repairs at household level through Emfuleni-type projects always receive the criticism of addressing tenants’ private problems with public funds. However, in this case, teaching tenants and house owners how to easily and cheaply carry out the necessary repairs has had a very positive impact. Firstly, the image of the municipality was remarkably enhanced through the support provided to customers. Secondly, a considerable sense of ownership could be reached on the part of the customers. Whilst in the first phase of the project 42% of the households had water loss-related problems, the re-visits carried out in the second project phase showed significant improvements (just 3% of the re-visited households had water-loss related problems).

- **Specific focus on schools**
  The schools in the area were initially targeted with a view to making the learners aware of the need to conserve water and to ensure that, at a young age, they understood the importance of preserving this scarce resource. These visits revealed that many schools had problems with the billing for water from the municipality. Critical support was therefore provided to the schools in respect of identifying where their meter was, helping them to understand the water bill and what factors affect it (some had very high consumption per learner), as well as training the caretakers to undertake basic plumbing repairs and to therefore deal with leaks as soon as they occurred. Thus, school programmes should not just focus on learners, but rather include principals and caretakers to ensure the improvement of school water infrastructure.

**Strengthening the role of the municipality**

Several recommendations derived from the project pertain to tasks and due diligence to be performed by municipal officials, including:
- Continued monitoring of water losses and speedy repair of leakages (including those on municipal property).
- Audits at abandoned buildings and residential properties to ensure that the water supply to these properties has been terminated. In many cases, these sites were used by car washers as water was freely available.
- Regular monitoring of work carried out by other contractors to prevent damage to the reticulation system and to ensure repair of damages as needed.
- Continued quality control of retrofitting programmes carried out in the communities.
- On-going training of water technicians and plumbers to understand the inter-relationship of the elements of the reticulation systems and the importance of maintaining the integrity of supply and pressure zones.

Emerging as part of the long-term solution to household water losses was the introduction of a household-level metering and...
billing system, which is supported by a comprehensive information strategy, for water supplied above the free basic service volume. This must be supported by the build-up of relevant enforcement capacity within the municipality and must be backed by strong political support on the need to pay for services supplied above the free basic level.

Project governance

- **Arrangements between partners**
  While Sasol and GIZ entered into a binding agreement also in terms of financial obligations, the MoU with the municipality was much less binding. This resulted in a certain degree of uncertainty for all project partners in terms of assuring delivery on commitment. While this did not cause major problems in the context of this project, contractual agreements need to be carefully designed in order for each partner to contribute according to available means and obtain the necessary legal security required by each partner involved.

  It was noted that the involvement of ‘neutral’ entities, such as ORASECOM and GIZ, had a positive impact on balancing the different interests, dynamics, pace and corporate cultures of the involved private and public partners.

- **Subcontracting and linking to performance-based contracting**
  Often water-loss reduction measures are carried out with the support of a service provider and/or managing consultant, which involves substantial subcontracting. The contractual agreements between the project partners should determine how the tendering and subcontracting will be carried out in order to satisfy the procurement rules of all respective partners.

  In this regard, performance-based contracting systems are emerging as a viable form to include service providers into such project contexts. As a follow-on activity of this project, considerable work has been done to develop a model performance-based contract that can be used by municipalities to procure service providers for similar water-loss reduction projects (SWPN 2015).

Backing and support at political level

In addition to political support on payment for services, support for measures at the operational level is crucial. This would not only include the ward management structure, but also from key decision-makers, such as the mayor, municipal manager, chief financial officer and councillors. In this case, whereas the project was generally viewed positively and supported by municipal leadership, the full buy-in of the financial department was yet to be realised. This mainly had effects on the use of savings from the ring-fenced account for project activities. A continued involvement of the finance departments is generally helpful. Only with high-level support will it be possible to maintain the sustainability of such efforts – through ensuring that the reduction in water use achieved during the project is maintained.

Support at the political level was also generated through a different channel in this project. From the onset of the process a representative from the transboundary Orange–Senqu River Basin Commission was part of decision-making bodies. With the Vaal River forming a tributary of the Orange–Senqu River catchment, this allowed for opening up the discussion and placing it into a broader catchment management context, thus unlocking an additional dynamic and momentum for project activities.

**FINAL REMARKS**

The Emfuleni water-loss reduction project is largely considered a very successful one, given the results obtained with regard to water and cost savings incurred by the municipality. Other, non-quantifiable benefits have also enhanced the overall positive outcome of the project.

Project partners encountered a number of individual and collective challenges during project implementation. These ranged from technical issues in relation to measures undertaken for water-loss reduction, to relationship aspects with regard to community interaction, political support, and arrangements between project partners.

Overall, challenges, if well managed, can be controlled. Lessons learned can be applied to potential replications of this approach in other southern African municipalities and water service providers.

**REFERENCES**


GIZ 2012: Orange River – Artery of Life, Brandes & Apsel, Frankfurt/Main.


**TEXT NOTES**

1. A performance and incentive-based rating scheme administered by the South African national government to assess municipalities’ performance in terms of water loss reduction.

2. The annual percentage increase in such water use has to be clearly defined, as this can be very different from the normally used growth projection in the number of households (in this project household growth was at 1% per annum while water demand growth was at 4% per annum).

In addition to political support on payment for services, support for measures at the operational level is crucial. This would not only include the ward management structure, but also from key decision-makers, such as the mayor, municipal manager, chief financial officer and councillors. In this case, whereas the project was generally viewed positively and supported by municipal leadership, the full buy-in of the financial department was yet to be realised.
INTRODUCTION

On-site water conservation and leak repair by municipalities in private properties is one of the strategies that can be employed to reduce water consumption. Lugoma et al. (2012) highlighted some studies that have been done on on-site leakage. They also highlighted some South African projects that realised water consumption reductions of between 20% and 38% due to on-site leak repair. Even though on-site water conservation and leak repair have been shown to be successful, and the benefits can be achieved in a relatively short period, it is not being done by most municipalities, because municipal policies and/or bylaws do not allow leaks to be repaired by municipal personnel on private properties (Wegelin et al. 2009).

The consumer is therefore fully responsible for any leaks that occur within the household property boundaries, and it remains his/her responsibility to pay for water consumed over and above the free basic water allocation, whether the water was consumed legitimately or as a result of leakages. Poor (indigent) households, however, cannot afford to pay for water services, or worse, pay for water services while at the same time experiencing on-site water leakages. The latter represents a double dilemma for a municipality that has a significant percentage of indigent households, as it would be losing high-quality water and revenue. This, therefore, makes on-site water conservation and leak repair especially relevant.

Prior to 2005, and after thorough analysis of water consumption data from indigent households, it became evident that very few indigent households within the City of Ekurhuleni (CoE) consumed water within the 9 kℓ/month free basic water provision allowed by the Indigent Support Policy of the Ekurhuleni Metropolitan Municipality (EMM 2006). In 2005, the CoE Municipal Council therefore approved the repair of leaks in indigent households by the municipality (EMM 2005). As a result, the CoE has been implementing on-site water conservation and leak repair in indigent households since 2008, the aim of the project being to identify indigent households with high volumes of water consumption, to minimise water losses in these households, to ensure that these households only consume the amount of water as allowed by the free basic water provision, and thereby sustainably achieve savings for the municipality.
water they need and can afford to pay for, and that the benefits of free basic water are realised.

While Lugoma et al (2012) highlighted the successes achieved by on-site leak repair, Mckenzie and Wegelin (2009)reported that, in numerous case studies, the projected savings, through a range of water demand management interventions, were either not achieved or proved to be unsustainable. This therefore raised the question about the sustainability of the water savings achieved through on-site water conservation and leak repair. This article analyses the data and discusses the findings regarding the sustainability of the benefits achieved by the on-site water conservation and leak repair project in indigent households in the CoE. Specifically, the article addresses the following objectives:

1. The efficacy of the on-site water conservation and leak repair project, i.e. to determine the extent of the reduction in leaks and water consumption in indigent households.
2. The financial efficacy of such a project for the municipality, i.e. to determine the cost of implementing the project and the financial benefits as a result of the decrease in unrecovered revenue.
3. The sustainability of the project benefits, i.e. to determine water consumption trends, water saving benefits, and consequently the financial benefits over three years.

**THE CITY OF EKURHULENI INDIGENT ON-SITE WATER CONSERVATION AND LEAK REPAIR PROJECT**

The implementation of this project broadly involved the following stages:

Assessing indigent household water consumption: As at September 2010, the City of Ekurhuleni had 43 439 registered indigent households in its database. As can be seen in Figure 1, 73.7% of these households consumed above 9 kℓ per month, with 44.1% consuming between 16 and 60 kℓ per month. It made sense therefore to target indigent households consuming above 9 kℓ, but most especially those consuming above 60 kℓ per month, for on-site water conservation and leak repair.

Auditing and investigation (pre-assessment): This stage involved the CoE consultants undertaking pre-inspection visits to the identified households and preparing job cards for the contractors to undertake the repairs/replacements.

**Repair or replacement of leaking or damaged fixtures**: During the project, all water fixtures within indigent properties that were damaged, or had reached the end of their service life, were repaired or replaced by the assigned contractor. These included repairing leaks within the connection pipe from the meter, leaking taps, leaking meters, leaking toilets and leaking geyser; replacing non-functional meters, complete toilets, and non-water-saving toilet cisterns with water-saving cisterns; and ensuring all meters were readable and active on the billing system. All repairs and replacements were done free of charge and this was a once-off benefit. Once the repairs/replacements were complete, completed job cards were submitted to the consultants.

Quality assurance and post-assessment: This stage involved post-inspection visits by the CoE consultants to the households, and inspection of a random sample of households by CoE officials.

Customer awareness: Property residents were then informed about the importance of saving water, how to save water, the impact of water consumption/wastage on their municipal accounts, as well as of their responsibility to thereafter maintain their household plumbing, and repair leaks.

**DATA ANALYSIS AND DISCUSSION OF FINDINGS**

**Data**

A data set comprising 473 indigent households was obtained from the CoE treasury. For each stand, details of the on-site water conservation and leak repair that were carried out, as well as details of monthly water consumption over 66 months (25 January 2009 to 25 June 2014), were obtained. The 66 months included the period before and after on-site water conservation and leak repair were undertaken. Of the 473 households, those with less than 95% of water consumption data over the 66 months were excluded from the data set. The final data set analysed in this article thus comprised 257 stands.

Analysis of repairs and replacements

The number and types of repairs or replacements undertaken within the 257 indigent households were aggregated and are presented in Figure 2.

Two hundred and forty non-water-saving toilet cisterns were replaced with water-saving (9 litre) toilet cisterns. Two hundred and twenty-two of these households had only one toilet cistern replaced, nine households had two replaced. Fifty-nine toilet cistern internal fittings were repaired. Of these, 49 were in households that required one toilet repair and five were from households that required two toilet repairs. In 23 households, the entire toilet was replaced. Of the 186 internal tap repairs, 124 were within indigent households that required one tap repair, 58 were within 29 households that required two tap repairs, while one of the households required four tap repairs.

While 222 of these households had only one toilet cistern replaced, nine households had two replaced. Fifty-nine toilet cistern internal fittings were repaired. Of these, 49 were in households that required one toilet repair and five were from households that required two toilet repairs. In 23 households, the entire toilet was replaced. Of the 186 internal tap repairs, 124 were within indigent households that required one tap repair, 58 were within 29 households that required two tap repairs, while one of the households required four tap repairs. Only 12 households required the repair/replacement of on-site underground pipes from the meter.

From Figure 2 it is evident that the results above clearly agree with the findings by Mayer et al (1999; 2004) and Britton et al (2013) regarding toilets being the highest culprits in water leaks.
Water saving efficacy of the on-site project

The average monthly water consumption for each of the 257 indigent households was collated for the financial year before the implementation of the project (Year -1, i.e. July 2009–June 2010). Thereafter the average monthly water consumption for these indigent households was collated for the project implementation year (Year 0, i.e. July 2010–June 2011), and the three financial years after the implementation of the project (Year 1, Year 2, Year 3, i.e. July 2011–June 2014). Year -1 water consumption data was then compared with data for Year 0 – Year 3, and the average efficacy of the project determined (see Table 1).

It can be seen from Table 1 that the average reduction in indigent household monthly water consumption immediately post-implementation (Year 1) of the project amounted to more than 50% of consumption. The data for Year 0 indicates that the benefits of the ongoing project (reduced consumption of 9.78%) were evident during that year.

Figure 3 presents a breakdown of the different water consumption categories highlighted in Figure 1 over the five distinct periods highlighted in Table 1. The figure also provides interesting evidence of average reductions and increases in average water consumption after the implementation of the project in the 257 indigent households. The figure shows the significant reductions from 13.7% to 2.5%, and from 17.0% to 8.0% in the first financial year after project implementation in households consuming more than 60 kℓ/month and 31–60 kℓ/month respectively. These reductions resulted in the significant increases in indigent households consuming less than 15 kℓ/month, and therefore the reduction in average monthly water consumption of 50.76% highlighted in Table 1.

Perhaps the most significant highlight is the reduction in water consumption above 30 kℓ/month from 30.7% to 10.5% in the first financial year after project implementation.

Financial efficacy of the on-site project

The CoE spent a total of R4 465 557.83 on the on-site water conservation and leak repair/replace activities. Of this amount, R2 094 539.83 was spent on leak repair/replace activities, and R2 371 019.00 on water conservation activities (replace toilet cisterns and replace/repair internal and external taps). The CoE also spent R6 210 577.34 on the management of the project, and R1 221 343.45 on the monitoring of the project. Table 1 shows the breakdown of the different types of repairs and replacements conducted, and Figure 2 shows the number of indigent households per consumption category as at September 2010.

### Table 1: Indigent household average water consumption before, during and after project implementation

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<th></th>
<th>Before implementation</th>
<th>During implementation</th>
<th>After implementation</th>
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<td>Year -1 July 2009 to June 2010</td>
<td>Year 0 July 2010 to June 2011</td>
<td>Year 1 July 2011 to June 2012</td>
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<tr>
<td>Average monthly household consumption (kℓ/month)</td>
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<td>Average reduction (kℓ/month)</td>
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<td>4 001.49</td>
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<td>% Average reduction</td>
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<td>50.76%</td>
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</tbody>
</table>
repair project in the 2010/2011 financial year. This cost included costs for all the indigent households assessed (pre- and post-) and the repairs/replacements carried out. For the purpose of this article, the average project cost per household was determined by only considering indigent households where assessment, repair and/or replacement were carried out. Households that were assessed, but for which no repairs/ replacements were undertaken, were excluded from the determination of the average cost. Average cost amounted to R1 206.53 (excluding VAT) per indigent household, and hence a total cost of R310 078.21 for 257 indigent households.

The financial benefit to the CoE from the implementation of the project is reduction in the volume, and consequently cost, of bulk water purchased from Rand Water (who is the CoE’s water service provider). The Rand Water bulk water tariffs during and after project implementation (R4.03 for 2010/2011; R4.55 for 2011/2012; R5.06 for 2012/2013; and R5.56 for 2013/2014) were used to determine the savings realised by the CoE, and this cumulatively amounted to R438 938.10 at the end of the third financial year (Table 2) for the 257 indigent households. Payback was therefore achieved early into the second financial year after project implementation.

Sustainability of benefits
The mean monthly water consumption for all households was determined and plotted in Figure 4. Data for the period 25 January 2009 to 25 June 2010 was used to determine the water consumption trend line before the implementation of the project. Data for the period 25 July 2011 to 25 June 2014 was used to determine the water consumption trend line after the implementation of the project.

The water consumption trend lines before and after the implementation of the project, as illustrated in Figure 4, show the short-term (July 2011–June 2014) impact of the project. Of particular significance, is the average water consumption which could have increased to approximately 54 kl/household/month at the end of June 2014 had the on-site water conservation and leak repair project in indigent households in the CoE. The article analyses water consumption and repair/replacement data from 257 indigent households. Highlights from the analysis include the following:

1. The most prolific sources of on-site water leaks in indigent households were toilets and taps.

Table 2: Financial cost versus benefit analysis

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (€) / Benefit (€)</th>
<th>Nett Cost (€) / Benefit (€)</th>
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<tr>
<td>Cost of project for 257 indigent households</td>
<td>-R310 078.21</td>
<td>-R310 078.21</td>
</tr>
<tr>
<td>End of Year 0</td>
<td>R39 771.26</td>
<td>-R270 306.95</td>
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<tr>
<td>End of Year 1</td>
<td>R233 074.84</td>
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<td>End of Year 2</td>
<td>R242 970.47</td>
<td>R205 738.36</td>
</tr>
<tr>
<td>End of Year 3</td>
<td>R233 199.74</td>
<td>R438 938.10</td>
</tr>
</tbody>
</table>

Figure 3: Different water consumption categories over the four distinct periods

Figure 4: Trends of average monthly water consumption per household before and after the implementation of the project

SUMMARY
The aim of this article was to determine the sustainability of the benefits achieved by the on-site water conservation and
2. The average reduction in indigent household monthly water consumption due to the project amounted to more than 50%. Of particular significance was the reduction in water consumption above 30 kℓ/month from 30.7% to 10.5% in the first financial year after project implementation.

3. The savings realised by the CoE cumulatively amounted to R438 938.10 at the end of the third financial year for the 257 indigent households, and thus payback was achieved early into the second financial year.

4. An implication of the above results is that the average monthly consumption per indigent household at the end of the third financial year after implementation of the project (June 2014) was ~42% lower (19.12 kℓ/month) than what it had been prior to the implementation of the project (32.72 kℓ/month), and ~65% lower than what it may have been (54 kℓ/month) had the project not been implemented.

Municipalities all over South Africa will therefore benefit immensely from undertaking similar assessment and on-site water conservation, repair and/or replacement.

REFERENCES


THE CITY OF TSHWANE (CoT) Water Resources Master Plan concerns the possible upgrading or extension of the CoT’s own water resources, with a view to reducing the dependence on imports from the Vaal River basin (via Rand Water). It also concerns the Olifants River basin and the Crocodile River basin, which receive significant sewer return flows from the CoT, influencing the yields of the local water resources and water allocations to downstream users.

The catchment areas of the above rivers and the boundaries of the CoT are illustrated in Figure 1, as well as the boundaries of all the surrounding metros and local municipalities. The CoT water system also supplies water to portions of Madibeng (Klipgat area), Moretele, Johannesburg (Midrand area) and Thembisile. External sewer flow is received from Johannesburg (Midrand area) and Ekurhuleni (Kempton Park area).

Figure 1: Catchment areas and the City of Tshwane Metropolitan Municipality boundaries
CURRENT WATER SOURCES AND DEMAND
On the basis of bulk water meter information from all the water sources, the CoT had a potable water Annual Average Daily Demand (AADD) of 940 Mℓ/d in 2012, which includes water exported to the neighbouring municipalities. Approximately 72% of the total AADD is supplied by Rand Water (Vaal River water) and most of the rest is generated internally by the CoT’s own fountains, springs, boreholes and Water Treatment Plants (WTPs), of which the Rietvlei WTP (40 Mℓ/d), Roodeplaat WTP (60 Mℓ/d), Bronkhorstspruit (54 Mℓ/d) and Temba WTP (60 Mℓ/d) are the largest. Magalies Water also owns and operates three WTPs which supply the CoT, namely Klipdrift WTP (18 Mℓ/d), Wallmannsthal WTP (12 Mℓ/d) and Cullinan WTP (16 Mℓ/d).

CURRENT WASTEWATER TREATMENT WORKS AND SEWER FLOW
The CoT straddles the water divide between the Crocodile River basin in the west and the Olifants River basin in the east. Approximately 505 Mℓ/d is discharged into the rivers as sewer Average Daily Dry Weather Flow (ADDWF) returns. Of this 96% (485 Mℓ/d) ends up in the Crocodile River basin, and only 4% (20 Mℓ/d) in the Olifants River basin.

The main CoT Wastewater Treatment Works (WWTWs) discharging in the Crocodile River basin are Sunderland Ridge (95 Mℓ/d), Baviaanspoort (60 Mℓ/d), Zeekoegat (30 Mℓ/d), Daspoort (60 Mℓ/d), Rooiwal (245 Mℓ/d), Temba WWTW (12 Mℓ/d), Rietgat (27 Mℓ/d), Sandspruit (20 Mℓ/d) and Klipgat (55 Mℓ/d).

In addition, ERWAT’s Olifantsfontein (105 Mℓ/d) and Harbeesfontein (45 Mℓ/d) WWTWs also discharge Ekurhuleni’s sewer flow into the Crocodile River basin upstream of CoT.

The main CoT WWTWs discharging into the Olifants River basin are Cullinan (2 Mℓ/d), Reihwe (2 Mℓ/d), Rayton (1 Mℓ/d), Godrich (5 Mℓ/d) and two maturation pond systems serving Ekangala.

FUTURE WATER DEMAND AND SEWER FLOWS
In accordance with the CoT current water and sewer master plans, which have been based on the approved Spatial Development Framework (SDF), the CoT AADD is set to increase over the next 45–50 years to 2 591 Mℓ/d, with concomitant increase in ADDWF to 1 593 Mℓ/d.

The anticipated future AADD will require a growth rate of ± 2% p.a. (within CoT), which is not altogether unrealistic, given historical statistics. There are, however, a few very large sections with many future development areas where growth may or may not realise as anticipated. These were taken cognisance of in the context of this study, since it may have a significant effect on sewer return flows and therefore the water resource availability at certain points in the Crocodile River basin. The development areas considered are:

An important criterion of the analysis was that the assurance of supply for all users would not be impacted through the extension of utilisation of the CoT local resources. This includes both the existing downstream users (predominantly irrigation) and the requirements of future MCWAP transfer to the Lephalale supply area, where the projected water requirements associated with planned developments in the area exceed the water resource availability of the local Mokolo Dam. The criteria ensured alignment with the DWS Crocodile West Reconciliation Strategy.
R21 Corridor (extends into Ekurhuleni)
Western Centurion
East of Silver Lakes
Doornpoort (north of Montana)
Kameeldrift/Derdepoort area (southwest of Roodeplaat Dam)
Goudveld/Carletonville (southeast of Soshanguve)
South of Temba

WATER RESOURCES SITUATION

The local water resource yields of the Crocodile River tributaries, which are the sources of the main CoT and Magalies Water WTPs, are all very much dependent on sewer return flows.

The CoT finds itself in an interesting conundrum concerning its potable water resources. On the one hand the Department of Water and Sanitation (DWS) has not approved the Rand Water application for increased abstraction above its current licence from the Vaal, which will only be resolved by around 2021 when the second phase of the Lesotho Highlands Water Project (Polihali Dam) is implemented. On the other hand, increases in the CoT’s sewer return flows into the Crocodile River basin are important from the perspective of generating sufficient yield to support the Eskom coal-fired power plants in Lephalale through the proposed inter-basin transfer (Mokolo Crocodile (West) Augmentation Project (MCWAP)).

Developing or extending the CoT’s own water resources will reduce the transfer from and load on the Vaal River system (via Rand Water), but will decrease the sewer return flows, which are required for the Eskom/Lephalale supply.

In the Olifants River basin all DWS-allocated licences for water abstraction are already being exceeded, and water is imported from the Vaal River via a pumping scheme that delivers water into the Ekandustria reservoirs, for supply to Thembisile.

WATER RESOURCE ANALYSES

The location of the CoT WTPs and WWTWs (including ERWAT WWTW contributing to the Crocodile River catchment) are illustrated in the simplified schematic representation in Figure 3.

The purpose of the water resource analysis was to establish the current and projected future yields of the local water resources, with the effect of the current and the future WWTW return flows incorporated, and to thus confirm the possible upgrading or extension of the CoT’s own water resources while maintaining the assurance of supply to the users downstream in the system.

The DWS has developed reconciliation strategies for both the Crocodile West and Olifants River basins, and information from these strategies was incorporated to ensure alignment between the two processes.

The water resources analysis of both the Crocodile West and the Olifants River basins was conducted by configuring the DWS Water Resources Planning Model (WRPM) to incorporate the selected water requirement and return flow projection scenario. Stochastic risk analysis was conducted to estimate the projected surplus yield available.

An important criterion of the analysis was that the assurance of supply for all users would not be impacted through the extension of utilisation of the CoT local resources. This includes both the existing downstream users (predominantly irrigation) and the requirements of future MCWAP transfer to the Lephalale supply area, where the projected water requirements associated with planned developments in the area exceed the water resource availability of the local Mokolo Dam. The criteria ensured alignment with the DWS Crocodile West Reconciliation Strategy.

The latest MCWAP requirements (balance between the Lephalale requirements and available yield from the Mokolo Dam) were sourced from the DWS MCWAP: Phase 2: Post Feasibility Bridging Study which was used for the planning analysis.

The total surplus yield confirmed in the WRPM analysis was compared against the MCWAP requirements, as illustrated in Figure 4. The surplus yield predominantly consists of surplus yield in the Hartbeespoort Dam, Roodeplaat Dam, Rietvlei Dam, the Apies River system and other smaller sources as indicated.

The most feasible options for the CoT to expand its WTPs were identified as the Rietvlei Dam, the Roodeplaat Dam and the possible utilisation of the Olifantsfontein WW TW return flows which contribute to the surplus yield in the Hartbeespoort Dam.

The total surplus yield of the most feasible options for the CoT to further expand its WTPs are illustrated in
The results of the WRPM analysis of the Olifants River basin showed that the users cannot be supplied according to their required assurance criteria, and the following interventions will be required to ensure sufficient water resource availability:

- Total surplus yield from Rust de Winter Dam required as support
- The successful implementation of WCDM initiatives
- Additional augmentation of approximately 14 Mm$^3$/a.

**POTABLE WATER TREATMENT PLANTS**

Based on the water resource analysis results the Rietvlei WTP and Roodeplaat WTP are the most appropriate points for access to the additional water resources available in the Crocodile River basin. The reasons for this are that the sites house substantial established WTPs, which draw water from the two largest impoundments in the city, providing appropriate buffers and reservoirs for raw water storage.

The surplus yields in the Crocodile River basin are sufficient to allow the following:

- Stepwise increase of the Rietvlei WTP capacity from 40 Mℓ/d to 140 Mℓ/d
- Further increase of the Rietvlei WTP capacity to 240 Mℓ/d if water is transferred from the ERWAT Olifantsfontein WWTW to the Rietvlei Dam
- Stepwise increase of the Roodeplaat WTP capacity from 60 Mℓ/d to 240 Mℓ/d
- Increasing the Temba WTP from 60 Mℓ/d to 180 Mℓ/d in step with the peak summer requirements.

Additional capacity created at the Rietvlei WTP (with or without Olifansfontein WWTW transfer) can be efficiently absorbed into the bulk water distribution system. In order to efficiently utilise the additional Roodeplaat WTP capacity, it will be required to increase the supply into the Wallmannsthal system, thereby eliminating the need for any further Wallmannsthal WTP expansions.

There is no further yield available for the required increases in capacity at the Cullinan and Bronkhorstspruit WTPs. The only option for augmenting this shortage is additional supply from Rand Water into these two systems.

**WATER REUSE CONSIDERATION**

In utilising the available surplus yield from the Crocodile River basin, the CoT acknowledges the current and future reality that it has been thrust into a reuse situation, and that the City will have to adapt its water management practices where necessary. This motivates that, should the CoT continue along the path of water utilisation from within its own boundaries, it cannot be on the basis of conventional water treatment philosophies, but rather along the lines of a focused long-term reuse strategy which may be implemented over time.

**PROCESS REQUIREMENTS**

The surface raw waters in the CoT are generally eutrophied with low to
The surface raw waters in the CoT are generally eutrophied with low to moderate turbidities. The chemical character of the water indicates low to moderate nutrient loads but, in cases, fairly high loads of chemical constituents which originate from returned treated wastewater flows. The character of the raw waters indicate that Dissolved Air Flotation (DAF) should be selected as primary phase separation process. The Temba WTP generally has the most challenging raw water source and the additional inclusion of settling should be considered for this plant. Processes for advanced oxidation and disinfection, as well as processes for the removal of organic carbons, taste and odours are required at all plants. The process steps prescribed by the recent analysis are similar to those currently installed at the Rietvlei and Roodeplaat WTPs. A well-known example of the full reuse process is Windhoek’s Goreangab WTP, which includes pre-ozone, enhanced coagulation and flocculation, dissolved air flotation, rapid gravity sand filtration, ozone,
two applications of biologically active carbon, granular activated carbon, ultrafiltration, stabilisation, and finally disinfection. The City’s current WTPs at Rietvlei and Roodeplaat share a very similar process, with the following exceptions: limited application of enhanced coagulation and flocculation, no deliberate application of biologically active carbon and no application of membrane filtration. It may be possible to retrofit both these WTPs to the specification of the full reuse plant if required. Given Tshwane’s familiarity with the Rietvlei and Roodeplaat process, as well as the proven performance of this process, the analysis of the future expansions was based on the adoption of the same process.

**IMPLICATIONS ON SEWER RETICULATION**

The proposed extensions of the Rietvlei and Roodeplaat WTPs will have limited implications on the current Sewer Reticulation Master Plan for the CoT, since the pipes, pump stations and WWTW capacities will have to accommodate the sewer flows regardless of their origin. In the context of reuse, WWTW processes and operation must, however, be considered as the first-stage potable water treatment step and must be managed accordingly.

**COST ASPECTS**

For each of the schemes, capex requirements for all WTPs and bulk water infrastructure facilities were estimated and put into a financial model, together with calculated utilisation percentages, in order to determine the unit cost of water production and distribution, as well as the financing requirement. The model was set up to determine the unit cost on the premise that the scheme must have ‘paid off’ all capex, opex and financing costs (i.e. reach break-even) by year 2065, i.e. approximately 20 years after the last capex spent.

The Rietvlei and Roodeplaat total unit costs compare well with the current Rand Water tariff of R5.55/kℓ. Even with full reuse compliance, as for the Goreangab WTP in Windhoek, the unit costs are still lower than the Rand Water tariff.

The Temba WTP unit costs are high, mainly due to relatively low utilisation of the additional facilities. The Temba WTP is, however, the only option for supply to the Temba system. There is therefore no change to or impact on the current master plan in terms of distributing the bulk water into the system. Calculation of unit costs for bulk distribution of water and comparisons with Rand Water are therefore superfluous.

The bulk water distribution unit costs for the Cullinan and Bronkhorstspruit augmentation scheme are relatively low, but the water has to be bought at R5.55/kℓ from Rand Water. The institutional matter of who is to finance, build and operate the scheme will have a bearing on the costs payable by the CoT, and has to be resolved with Rand Water.

**RAND WATER TRADE-OFFS**

A comparison between the current Bulk Water Master Plan situation and the adjusted Master Plan based on this Water Resources Master Plan indicates the following effective trade-offs between Rand Water supply and the possible extended own water sources, in the Master Plan horizon year of 2058:

- Rand Water supply reduces from 2 022 Mℓ/d AADD to 1 815 Mℓ/d (207 Mℓ/d reduction). The above supply includes augmentation of 22 Mℓ/d AADD and 60 Mℓ/d AADD to Cullinan and Bronkhorstspruit.
- Supply from Rietvlei WTP (including Rietvlei Springs contribution) increases from 48 Mℓ/d AADD to 240 Mℓ/d AADD (192 Mℓ/d increase).
- Supply from Roodeplaat WTP increases from 111 Mℓ/d AADD to 218 Mℓ/d AADD (108 Mℓ/d increase).

**CONCLUSIONS**

There is sufficient surplus yield available in the Crocodile River basin for the CoT to increase the capacities and supply areas of the Rietvlei and Roodeplaat WTPs, and it can be achieved at a unit cost of water lower than the Rand Water tariff. There is also sufficient yield available to expand the Temba WTP in step with the increase in demand.

The surplus yields available from the analysis are dependent on and can be influenced by the following:

- The future return flows generated by the CoT and Ekurhuleni WWTWs, which in turn are affected by developments in some large areas, which may or may not realise as anticipated in the projections.
- The MCWAP water requirement projection, which historically has been adjusted according to the uptake in planned developments.

It is recommended that the water requirements and return flows are continually monitored, and that the analysis is revisited, should noticeable differences occur between the actual recorded figures and the assumed scenario.

There is no surplus yield available in the Olifants River basin for expansion of the Cullinan, Bronkhorstspruit and Bronkhorstbaai WTPs. The results of the water resource analysis showed that the users cannot be supplied according to their required assurance criteria, and the following interventions will be required to ensure sufficient water resource availability:

- Total surplus yield from Rust de Winter Dam required as support.
- The successful implementation of WCDM initiatives.
- Additional augmentation from Rand Water to Cullinan and Bronkhorstspruit.

**PROJECT TEAM**

The study was undertaken on behalf of the client, City of Tshwane Water and Sanitation Planning Division, by GLS Consulting, WRP Consulting Engineers and CSW Water Consulting Engineers.

For each of the schemes, capex requirements for all WTPs and bulk water infrastructure facilities were estimated and put into a financial model, together with calculated utilisation percentages, in order to determine the unit cost of water production and distribution, as well as the financing requirement. The model was set up to determine the unit cost on the premise that the scheme must have ‘paid off’ all capex, opex and financing costs (i.e. reach break-even) by year 2065, i.e. approximately 20 years after the last capex spent.
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INTRODUCTION

South Africa is currently facing an energy crisis which places additional importance on harvesting all available and feasible renewable energies. While the country is not particularly endowed with hydro-power conditions, large quantities of raw and potable water are conveyed daily under either pressurised or gravity conditions over long distances and elevations.

On 31 March 2015 the Minister of Water and Sanitation, Nomvula Mokonyane, unveiled Bloemwater’s conduit hydropower facility at the Brandkop Reservoir, and celebrated the major scientific and engineering achievements made by the team of researchers.

Bloemwater Conduit Hydropower Plant launched
The University of Pretoria (UP), supported by the Water Research Commission (WRC) and collaborating organisations such as the City of Tshwane Metropolitan Municipality, Bloemwater and the eThekwini Municipality, was engaged in a research project to investigate and demonstrate the potential of extracting the available energy from existing and newly installed water supply and distribution systems.

The aim of the project was to enable the owners and administrators of bulk water supply and distribution systems to install small-scale hydropower systems to generate hydroelectricity for use on site and, in some cases, to supply energy to isolated electricity demand clusters, or even to the national electricity grid, depending on the location, type and size of installation. It taps into a previously unutilised source of hydropower by using excess energy in pressurised conduits to produce clean and renewable hydroelectric power.

This type of energy generation, referred to as conduit hydropower, is different to conventional hydropower generation where large dams are used to store river water in a reservoir. Its simplicity is what makes this solution so elegant – harnessing energy that is already present within the existing infrastructure and that would usually be lost through a pressure reducing valve. As part of the research project two reports detailing the entire process were compiled: Conduit Hydropower Development Guide (WRC Report No TT597/14) and Conduit Hydropower Pilot Plants (WRC Report No TT596/14).

BACKGROUND
An initial scoping investigation by the WRC and UP highlighted the potential of hydropower generation at the inlets to storage reservoirs (Van Vuuren 2010). In South Africa there are 284 municipalities and several water supply utilities and mines, all owning and operating gravity water supply distribution systems which could be considered for small-, micro- and pico-scale hydropower installations. The WRC and Bloemwater entered into a partnership to install the first full-scale demonstration unit for conduit hydropower in South Africa.

The Caledon–Bloemfontein potable water supply system is responsible for supplying most of the water to the Bloemfontein area and was commissioned in the late 1960s. The supply system has a design capacity of 141 Mℓ/day (1.632 m³/s).
Figure 4: A pictorial view of the development of the Bloemwater Conduit Hydropower Plant at the Brandkop Reservoir.
With the exception of the Welbedacht Dam, the Department of Water and Sanitation (DWS) transferred the assets to Bloemwater in 1991.

The Caledon–Bloemfontein pipeline supplies potable water from the Welbedacht Dam in the Caledon River to Bloemfontein. The treated water is pumped a distance of 6.7 km with a high-lift pump station to the De Hoek Reservoir (22.7 Mℓ). From here it gravitates through a 1,168 mm Ø prestressed concrete gravity main 47 km to the Uitkijk Reservoir (22.7 Mℓ). From here it gravitates through a 1,168 mm Ø prestressed concrete gravity main 47 km to the Uitkijk Reservoir (22.7 Mℓ). From here it gravitates through a 1,168 mm Ø prestressed concrete gravity main 47 km to the Uitkijk Reservoir (22.7 Mℓ). From here it gravitates through a 1,168 mm Ø prestressed concrete gravity main 47 km to the Uitkijk Reservoir (22.7 Mℓ).

Excess energy is dissipated through pressure control valves upstream of the Uitkijk and Brandkop Reservoirs before being discharged into the reservoirs (see longitudinal profiles in Figure 3). In order to determine the energy potential at the inlets into the two reservoirs (Uitkijk and Brandkop) the pipelines were hydraulically assessed and the available pressure head and flow rate recorded for a number of months. This assessment indicated that there were approximately 350 to 400 kW available at each of these sites.

For the first phase, Bloemwater decided to develop a hydropower plant with sufficient capacity to meet the electricity demands of its head office, which is situated at the Brandkop Reservoir. Pressure head and flow were measured for the hydraulic assessment, and electricity consumption data was recorded to determine the correct turbine for the demand. The turbine and generator are housed in a turbine room located next to the Brandkop Reservoir. On average, approximately 30% of the water supplied via the Caledon–Bloemfontein pipeline is diverted through the turbine (350 ℓ/s at 40 m pressure head). After passing through the turbine generator, the water is discharged through a constructed opening in the roof of the southwest corner of the reservoir.

Based on the available pressure head range and fixed flow rate of 350 ℓ/s, it was decided to select a 96 kW crossflow (Banki) turbine. The type of turbine selected was the IREM ECOWATT Micro hydroelectric power plant type TBS 4-0.5 with synchronous generator. Electronic regulators are connected to provide the dissipating capability – 9 x RMP 12000/B with a total capacity of 108 kW. The regulators keep the voltage and frequency stable as the absorption of the electricity produced by the turbine generator group remains constant, providing clean, stable electricity at the correct voltage and frequency of 50 Hz. Sufficient renewable electricity is generated to supply the peak demand of Bloemwater’s head office, as well as to meet the electricity requirements of the reservoir terrain. The theoretical annual energy that can be generated with this plant is 837,500 kWh, based on average flow and pressure values.

THE HYDROPOWER PLANT
A pictorial view of the development of the Bloemwater Conduit Hydropower Plant is shown in Figure 4.

FINANCIAL VIABILITY OF THE PROJECT
The feasibility study conducted for this installation made some assumptions.
regarding the design life (40 years), anticipated electricity escalation (8%) and the discount rate (7%) on the investment made by Bloemwater. It also looked at the current monthly spending of the Bloemwater head office on electricity, which resulted in a payback period of 72 months. The aim was to make this system viable without receiving special subsidies or tariffs. The success and short payback period have given Bloemwater the confidence to start planning the next phase and conducting feasibility studies for other potential conduit hydropower sites. The total cost for this project was R3 500 000 or R36 500/kW.

The plant is not utilised to its full potential, as the peak 96 kW is only required during the peak demand hours of the day. After hours and during weekends the plant will only operate at 30% of its capacity. Thus the potential is there to utilise this more efficiently.

SUCCESS OF THE PROJECT

The plant has now been operational since the launch, supplying Bloemwater with hydroelectric power even when other parts of town are left in the dark during load shedding. This is an example of basic innovative research being implemented practically. It is believed that the research which provided this working demonstration plant has inspired the uptake of conduit hydropower in South Africa. Already several other potential conduit hydropower sites have been identified, investigated, put out to tender and constructed, or are operational at Rand Water, Mossel Bay Municipality, George Municipality, Lepelle Water, Amatola Water, Bloemwater, eThekwini Municipality, City of Tshwane, Johannesburg Water, City of Cape Town and Eskom, amounting to 38.6 MW. This has a monetary generating value of R220 million/annum. Further estimates point to an additional 59.8 MW of untapped potential in the larger metropolitan areas alone, with monetary generating value of R340 million/annum excluding all the mines.

This will provide temporary employment during the construction stage, and direct employment opportunities in operation and maintenance at some of these power plants.

Conduit hydropower uses the available water supply and distribution infrastructure and thus, as long as there is a demand, hydroelectric energy can be generated. As conduit hydropower ‘piggybacks’ on existing water infrastructure, it also has minimal negative environmental impact.

Hydropower schemes generally have very long lifespans with low operating and maintenance costs (USBR 2008). Furthermore, hydroelectric energy technology is a proven technology that offers high efficiencies, as well as reliable and flexible operation (ESHA 2009).

Conduit hydropower requires a relatively small capital investment and has a short return on investment period. As long as society uses water, renewable hydroelectricity can be generated. At the Bloemwater Conduit Hydropower Plant the water supply system and the electricity consumption were carefully monitored for a number of months before selecting the most suitable turbine and installation configuration for optimal operation.

From the start the Bloemwater Board gave its full support to this new endeavour. South Africa only has a handful of conventional hydropower schemes, but Bloemwater took the bold step by investing in conduit hydropower, and also assisted in knowledge dissemination and showcasing the application of this new technology.

To operate the system effectively a better understanding of the whole system is required. On this project, the supply of water from the WTW, the capabilities and characteristics of the pipeline system, the demand for water from the Brandkop supply reservoir and the electricity requirements for head office are now working as an integrated system. There is also a greater synergy between the various components, as they need to be operated and regulated collectively.

Bloemwater has successfully exploited this productive synergy between the water and energy systems.

Please also visit www.youtube.com/watch?v=um4zlK53hrs to view the YouTube video of this project – The Power of Hydro: Bloemwater Conduit Hydropower Plant Project.

ACKNOWLEDGEMENT

The research project was funded by the Water Research Commission whose support is acknowledged with gratitude.

BIBLIOGRAPHY


(Accessed 5 September 2011).


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• Transverse stiffeners reduce the deflection of the pan, increasing the wind uplift resistance.
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Delivering the Exceptional
BACKGROUND

The abstraction of water at mines is an ongoing challenge requiring innovative solutions in order to have little or no impact on mining production. Pump stations often need to be demolished and rebuilt as mining activities move around. Construction on mining property is, however, becoming more and more challenging due to regulations. Contractor health and safety inductions, amongst others, have become a lengthy and expensive process which directly impacts the construction phase.

The ‘plug-and-play’ approach, which is well-known in digital technology, is proving to be successful when applied in the mining sector. Termed ‘modular solutions’, the idea of constructing complete pump stations in a modular building has delivered promising results.

Pumping assemblies are installed in modular buildings at the factory and delivered to the mine. These pump stations can then be installed to a large extent by the employer’s own staff. This greatly reduces the amount of labour and time needed from contractors on site. Furthermore, it limits the impact on mining production as it reduces the construction period. Commissioning of the pump stations can be completed at the factory which, in turn, offers better quality control.

PROJECT DESCRIPTION

BHP Billiton Manganese Mines consulted engineering, management and specialist technical services group Aurecon to develop an effective solution to increase the peak flow capacity of its dewatering infrastructure, for commissioning during June 2015 (which was indeed the project status at the time of preparing this article).

The concept of a modular pump station was then tabled, as it is ideal for remote areas where engineering and mainte-
nance services are limited. It further allows for shorter turn-around times on manufacturing. Modular pump stations also provide the option of removing the assembly and reinstalling it elsewhere. The client was open to the concept, and end-suction centrifugal pumps were selected to provide a maximum flow of 40 t/s at a differential head of 25 m. The pumps operate under a flooded suction under gravity from a nearby supply reservoir.

Efficient Engineering, a sheet metal fabrication, machining, manufacturing and heavy-duty engineering works, was awarded the contract to design, manufacture and install the pump station. Aurecon was appointed as the consulting engineers to review the contractor’s detailed design.

The pump station was designed to allow for fast and easy installation on site. All control panels and motor control centres were installed inside the building. Suction and discharge pipework connections allowed for easy integration with the existing piping infrastructure. Where possible ancillary equipment, such as flow meters, isolation valves and pressure transmitters, were installed in or near the modular building to add to the term ‘modular pump station’.

Ancillary equipment further away from the building can be installed by either the employer’s personnel or a small team from the contractor. These activities generally have little impact on mining activities. Such ancillary equipment, for example substations and telemetry equipment, can also be provided as complete modular units.

CONCLUSION

The simplicity of complete modular pumping solutions with a ‘plug-and-play’ approach has proved to be an effective and promising approach for dewatering and water distribution infrastructure in mining areas. The advantage of manufacturing and installing equipment in a clean and controlled environment with more resources is advantageous to both the contractor and the employer.

Ancillary equipment further away from the building can be installed by either the employer’s personnel or a small team from the contractor. These activities generally have little impact on mining activities. Such ancillary equipment, for example substations and telemetry equipment, can also be provided as complete modular units.
INTRODUCTION

South Africa is a rapidly urbanising country with complex water management challenges, including significant resource shortages, fragmented institutional structures, as well as associated negative impacts on the quality of surface and groundwater resources. Alternative approaches to conventional water management, which aim to facilitate a change from ‘water-wasteful’ to ‘water-sensitive’ environments, are required if serious economic and socio-political threats are to be averted. Water Sensitive Urban Design (WSUD) is such an approach. It reflects a paradigm shift in the way urban environments are planned and designed so that issues of water sustainability and environmental protection are paramount, together with the provision of multiple benefits and opportunities to overcome specific challenges of water management.

The implementation framework and guidelines for the adoption of WSUD in South Africa have recently been published by the Water Research Commission (WRC) and provide a comprehensive summary of the approach, its principles and strategies. WSUD is seen as the enabler for moving South African institutions and local authorities closer to meeting developmental goals, as set out in the National Development Plan, and the objectives of the Water for Growth and Development, National Water Resource, and Climate Change strategies. However, if South Africa is to advance the notion of WSUD there needs to be a societal openness – including building political will and ensuring financial investment – to embrace a water-sensitive design vision as part of the broader developmental vision. This is likely to involve, *inter alia*:

- reorganising planning departments and processes
- adopting new technologies and adapting old technologies
- reviewing and applying new policy and legislation
- building capacity (skills, competencies and judgement)
- initiating demonstrators for technology transfer with partners, actors and stakeholders
- ensuring that the principles of WSUD are increasingly rapidly understood and accepted by on-the-ground water users.

In early 2014, as a first step towards advancing a water-sensitive design vision for South Africa, the WRC called for proposals
Example of a detention pond at The Falls Pick 'n' Pay, Roodepoort (Photo: D Ellis)

Bio-swales collect and treat stormwater from The Falls Pick 'n' Pay parking area for later use as irrigation water (Photo: D Ellis)

A canalised section of the Liesbeek River (Photo: K Winter)

A section of the concept plan for the Liesbeek River Life Plan (Rose Buchanan: Landscape & Design)
regarding the development and management of a Water Sensitive Design Community of Practice (WSD CoP) programme. The overall aim of the programme is to identify and disseminate the necessary information to ‘tell a clear story’ about WSUD in South Africa, such that the critical linkages between the various aspects of this new water management paradigm are highlighted during engagement with a wide range of cross-disciplinary stakeholders. In particular, the CoP will attempt to address the notion of managing the complexity inherent in an approach such as WSUD in order to develop an intellectual contribution in this regard, and to ensure that it can influence planning and the alignment of governance aspects at a high level.

The Urban Water Management (UWM) research unit at the University of Cape Town was awarded a five-year contract (starting in June 2014) to establish this WSD CoP programme so that the implementation of WSUD in South Africa can be advanced, and in particular so that the knowledge sharing and capacity development required to encourage a paradigm shift in the water sector can be addressed. The main focus areas therefore are the development and maintenance of an information transfer system (website/database), and the identification of possibilities for collaborative and participatory interaction between all relevant actors. This also includes awareness-raising and appropriate WSUD training activities – using the recently published framework and guidelines as a starting point – as well as attempts to strengthen and broaden the researcher base, both across disciplines as well as amongst different institutions.

**PROJECT DESCRIPTION**

Identifying and reporting on examples of best practice in WSUD around the country is considered to be one of the best ways of transferring information and influencing uptake of these principles. The first phase of the project has thus involved the collection of project-related information, and a project register has been established to aid in the broad identification and consolidation of WSUD practices throughout the country, with the primary aim of informing the prioritisation of specific case study reviews. Project components such as location, completion date, primary purpose, noteworthy history, WSUD strategies and general measures of project success are recorded in a database via an online input form. Recorded information is condensed into visually attractive, one-page statements that are distributed via the project website. In addition, the relevant actors and the roles they play within the projects are highlighted, along with links to websites, where possible. Such detail is aimed at providing stakeholders a level of exposure within the developing CoP and to encourage transfer of information if their projects are selected for detailed review.

Awareness-raising and training activities associated with this project are being addressed in multiple ways. These include:

- the development and monitoring of appropriate WSUD Learning Alliances (platforms which enable stakeholders from a range of institutions, e.g. local authorities, service providers, universities, NGOs and user groups, to test ideas and learn together), and/or municipal task groups;

**COMPANY BACKGROUND**

Escongweni Engineers is a 100% Black African owned consulting engineers company, which has been in existence since 2005 and rebranded to Escongweni Engineers in 2014. Upon rebranding after nine successful years we expanded to two additional branches, in Bloemfontein and Johannesburg.

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www.escongweniengineers.co.za
writing articles, press statements, blogs and opinion pieces; and
presenting at conferences, and holding workshops and seminars on different aspects of WSUD.

In order to provide specific opportunities for engagement, and to drive WSUD mechanisms on a broader scale, the UWM research unit is involved in several WSUD-related information exchange platforms around the country. This article describes in some detail one of these platforms – a recently formed collaborative effort with the Friends of the Liesbeek (FoL) in Cape Town on a project called The Liesbeek River Life Plan.

The main aim of this plan is to provide new knowledge and designs for the Liesbeek River to improve the ecological conditions in the river corridor, and simultaneously protect and boost its social and amenity value. A secondary aim of the plan is to explore new ways of thinking, based on the knowledge and experiences of participants, i.e. it acts as a Learning Alliance. One of the main focus areas of the plan is therefore on the development and inclusion of citizens’ contributions to the river rehabilitation process, and as such it provides an excellent opportunity for the sort of social learning envisaged through the broader WSD CoP programme as a whole.

LIESBEK RIVER LIFE PLAN - PROJECT STATUS

The City of Cape Town has managed the Liesbeek River catchment since the 1920s, primarily through interventions aimed at reducing the risk of flooding to private properties and infrastructure. Almost a century later, and in the context of a city that has rapidly expanded towards the suburbs, nearly 70% of the river corridor is now canalised and formally attached to a network of stormwater pipelines that discharge runoff directly to the river.

The combination of residential properties creeping onto the Liesbeek floodplain and the dominant engineering paradigm of the day have contributed to an ecologically degraded river system, parts of which function largely as a stormwater drain. The unintended consequences of poor urban planning, and what are now perceived to be inappropriate solutions, are legacies that are difficult to overcome.

The UWM research unit has therefore been working with the FoL – and its wider working group represented by civic groups, neighbourhoods in close proximity to the river, city officials and elected councillors – on the design of a concept plan for the restoration of the Liesbeek River. The plan is geared towards assessing the potential for the implementation of WSUD options specifically aimed at alleviating flooding, improving river quality, increasing biodiversity, and enhancing the amenity value of the river corridor. This is achieved mainly through the use of sustainable urban drainage system (SUDS) components at local and regional scale, which include:

- filter strips
- swales
- bio-retention areas
- infiltration trenches
- detention/retention ponds
- constructed wetlands.

Additional opportunities for intervention in terms of creating multi-functional public spaces and improving river connectivity have also been explored.

Research activity on urban river restoration, integrated urban water management and new theories on governance have been growing in recent years, and it is now widely acknowledged that urban water issues are complex and can no longer rely on the input of particular disciplines, individuals or government officials alone. Additionally, it is recognised that if flooding is to be controlled in certain sections of an urban river, the entire river system needs to be managed, i.e. upstream interventions will also be required. Hence the UWM research unit has also been involved in several other model-based feasibility studies on the Liesbeek River system which address the potential for water-sensitive management, including the use of stormwater as a resource, greywater recycling, reducing on-site leakage, and installing water efficient devices.

The concept plan was completed at the end of 2014 and is being used to initiate further consultation with the various stakeholders and City of Cape Town officials. In this regard, a form of Learning Alliance has been established where new ways of thinking are explored based on the knowledge and experiences of a wide range of participants. One of the main outcomes of the Liesbeek River Life Plan has been the development and inclusion of citizens’ contributions to the river restoration process. As such, it adds another important dimension to the feasibility studies and provides an excellent opportunity for the sort of social learning envisaged through the WSD CoP programme as a whole.

CONCLUSION

The Liesbeek River Life Plan initiative presents an opportunity to contribute to reconceptualising the design and form of an urban river. Whilst a great deal of research data already exists on the Liesbeek River, the gap lies in interpreting and applying existing and further research findings in a collaborative process within a ‘Community of Practice’. The conceptual phase of the project is complete and the next phase involves drafting plans and designs for the planned modifications and interventions. Detailed plans, forged through cooperative learning processes, are necessary to bring the project to life and identify priorities, financial costs, practicalities and desirable outcomes. Taking the concept plan further will involve the development of a narrative so that it becomes an open and transparent effort in which a wider group of interested parties can express opinions, knowledge and experience.

The Liesbeek River Life Plan is but one example of the range of information exchange activities currently being undertaken as part of the WSD CoP programme. For further details on associated studies, actions and outputs, please consult the project website at www.wsud.co.za.

PROJECT TEAM

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Taking the concept plan further will involve the development of a narrative so that it becomes an open and transparent effort in which a wider group of interested parties can express opinions...
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INTRODUCTION

Aerobic granular sludge has been developed as an alternative to the activated sludge systems that are commonly applied for municipal and industrial wastewater treatment worldwide (including in South Africa). Activated sludge systems use floculent biomass which has relatively low settleability, necessitating large secondary settling tanks and low reactor biomass concentrations (3–5 gMLSS/l). In turn, activated sludge systems have a significant footprint (space requirement) and require a relatively large energy input (aeration and recycle pumping). In contrast aerobic granular sludge comprises more compact and dense bio-granules that result in improved sludge settling characteristics (up to > 10 m/h). Aerobic granular sludge is formed by applying specific process conditions that favour slow-growing organisms such as PAOs (polyphosphate-accumulating organisms) and GAOs (glycogen-accumulating organisms), and suppression of the growth of floculent biomass, together with selective wasting whereby slow-settling floc-like sludge is discharged and faster-settling biomass is retained.

Nereda® is Royal HaskoningDHV’s patented treatment technology that utilises aerobic granular sludge and has been used at full-scale for more than ten years in industrial wastewater treatment. The Nereda® solution for municipal wastewater treatment was developed through a collaborative public-private partnership involving Dutch wastewater treatment stakeholders, the Delft University of Technology in the Netherlands, various treatment plant end-users/operators such as the Overstrand and Stellenbosch Municipalities in South Africa and Royal HaskoningDHV. The Nereda® technology consists of a cyclical process with three main cycle phases, namely: simultaneous fill and draw, aeration/reaction and settling. The aerobic granules formed have excellent settling properties, allowing for higher biomass concentrations (8 gMLSS/l), the non-use of secondary clarifiers and the exclusion of major sludge recycle pumping in the Nereda® system. The result is a compact, simple system that requires significantly less chemicals and energy, but critically is able to match or better the effluent quality achieved by any activated sludge system, i.e. Nereda® is a technology that can achieve sustainable and cost-effective wastewater treatment.

The world’s first municipal demonstration Nereda® treatment system (5 Mℓ/d) was built at the Gansbaai Wastewater Treatment Plant (WWTP) for the Overstrand Municipality in the Western Cape, with the plant being commissioned in 2009. The Gansbaai Nereda® project was awarded the prestigious SAICE National Award for Technical Excellence in Civil Engineering in 2009, and the treatment plant was awarded Green Drop status in 2013. Following the realisation of the Gansbaai Nereda®, the technology has been successfully utilised at numerous municipal and industrial WWTs across the world, and this article provides an update on the status of the system, pro-
NEREDA® UPDATE

To date more than twenty full-scale Nereda® plants are in operation or under construction in South Africa, Portugal, Poland, Ireland, United Kingdom, Australia, the Netherlands and Brazil. Further Nereda® plants are in the planning and design phase, including plants with capacities exceeding 1 million PE (population equivalents) of 100 Mℓ/d. Exponential growth in the number of full-scale plants is occurring, with this trend expected to continue. The operational full-scale plants have all met effluent requirements whilst achieving energy and space savings, and lower chemical and energy use when compared to similarly loaded activated sludge systems – i.e. more sustainable wastewater treatment. Furthermore, a new possibility for extracting alginate-like polymers from aerobic granular sludge has emerged, which could provide interesting reuse opportunities for Nereda® waste sludge, thereby further enhancing the Nereda® system’s sustainability credentials.

Several Nereda® plant configurations have been developed to meet the full spectrum of wastewater treatment scenarios experienced from site to site and from country to country. The main plant configurations are detailed in Table 1.

### Table 1: Nereda® configurations

<table>
<thead>
<tr>
<th>No</th>
<th>Nereda® configuration</th>
<th>Typical layout</th>
<th>Attributes</th>
<th>Advantages</th>
<th>Reference examples</th>
<th>Potential applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3X reactors</td>
<td>3 reactors</td>
<td>At least 1 reactor fed at all times</td>
<td>Scalable for application to the world’s largest treatment challenges</td>
<td>Epe WWTP (Netherlands)</td>
<td>Greenfield sites; extension to existing plants with parallel Nereda® line</td>
</tr>
<tr>
<td>2</td>
<td>Buffer followed by X reactors</td>
<td>1 buffer + 2 reactors</td>
<td>Buffer stores between feeds to reactors</td>
<td>Optimised investments (2 reactors vs 3)</td>
<td>Wemmershoek WWTP (South Africa)</td>
<td>Greenfield sites; extension to existing plants with parallel Nereda® line</td>
</tr>
<tr>
<td>3</td>
<td>Hybrid</td>
<td>1 or more Nereda® reactors – connected to activated sludge system</td>
<td>Waste Nereda® sludge to activated sludge system</td>
<td>Improve activated sludge system performance / optimise existing infrastructure</td>
<td>Vroomshoop WWTP (Netherlands)</td>
<td>Brownfield sites; extension / optimisation scenarios with optimal use of existing infrastructure</td>
</tr>
<tr>
<td>4</td>
<td>Retrofit</td>
<td>Convert existing SBR / activated sludge reactor or any suitable existing tank</td>
<td>Use existing infrastructure</td>
<td>Cost-effective way to increase capacity and improve performance whilst using existing infrastructure</td>
<td>Frielas WWTP (Portugal)</td>
<td>Brownfield sites; space or budget constraints / capacity increase or improved performance required</td>
</tr>
</tbody>
</table>

In the Netherlands and Portugal, Nereda® plants have been built parallel to existing activated sludge systems, and this has facilitated long-term studies on operational full-scale plants in the planning and design phase.
sludge settleability improvements and effluent quality. Table 2 provides some pertinent results regarding energy usage and effluent quality from independent (non-Royal HaskoningDHV) sources.

Based on experience from treatment plants built to date, it is clear that Nereda® can achieve the following performance when compared to any similarly loaded activated sludge system:

- **Plant footprint:** 50–75% reduction
- **Energy usage:** 20–45% lower
- **COD removal:** equal or better
- **Biological nutrient removal (nitrogen and phosphorus):** equal/better
- **Simplicity of operation:** better

Nereda® allows for optimal simultaneous phosphorous and nitrogen removal in a single reactor.

**WEMMERSHOEK WWTP**

In 2010 the Stellenbosch Municipality decided to centralise wastewater treatment for the Franschhoek area by decommissioning two existing treatment plants (Franschhoek and La Motte WWTPs) and treating all wastewater at the Wemmershoek WWTP. To realise a cost-effective centralisation of treatment capacity a new 5 Mℓ/d treatment system was required at the Wemmershoek works. The Franschhoek area falls within the sensitive Berg River catchment which meant stringent effluent requirements. Royal HaskoningDHV proposed the Nereda® technology and effluent reuse as a cost-effective and sustainable means to meet the project requirements. By utilising Nereda® and partial effluent reuse (irrigation) the need for extensive tertiary treatment to meet expected future (even more stringent) standards was not required. Details of the treatment plant are provided in Table 3.

The new 5 Mℓ/d system was commissioned in August 2014 and, following the development of granular sludge, the treatment plant is producing excellent effluent quality (well below requirements) – see Table 4 for recent effluent results.

The data presented in Table 4 is based on average effluent results from March to April, independently verified by an external laboratory (CSIR). The Wemmershoek treatment plant has a discharge limit of 10 mgPO₄-P/ℓ. Although the phosphorus concentrations in the final effluent are well below this limit, the process control has not yet been fully optimised for biological phosphorus.

### Table 2: Energy use and nutrient removal performance at Nereda® treatment systems in the Netherlands with long-term monitoring

<table>
<thead>
<tr>
<th>Treatment plant</th>
<th>Energy use (relative to pollution load treated)</th>
<th>Nutrient removal performance</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epe</td>
<td>Performance monitoring in 2012 showed 40% lower energy consumption than activated sludge treatment systems in the Netherlands with similar tertiary treatment (sand filters)</td>
<td>Average effluent (March–May 2014): TN = 4 mgN/ℓ; NH₄-N = 0.1 mgN/ℓ; TP = 0.3 mgP/ℓ</td>
<td>STOWA</td>
</tr>
<tr>
<td>Garmerwolde</td>
<td>Energy consumption of the Nereda® installation (including intermediate pumping) was consistently more than 40% lower than the energy consumption of the parallel activated sludge (AB) system in 2014</td>
<td>2014 monitoring – met effluent requirements of: TP &lt; 1 mgP/ℓ; TN &lt; 7 mgN/ℓ</td>
<td>Waterschap Vallei and Veluwe</td>
</tr>
<tr>
<td>Vroomshoop</td>
<td>Monitoring at Vroomshoop (September–November 2014) showed the Nereda® side of the treatment plant used approximately 35% less energy than the activated sludge side</td>
<td>Average effluent (2014): TN = 7.2 mgN/ℓ; TP = 0.9 mgP/ℓ; Ortho-P = 0.6 mgP/ℓ</td>
<td>Waterschap Vechtstroomen</td>
</tr>
</tbody>
</table>

### Table 3: Wemmershoek WWTP design details

<table>
<thead>
<tr>
<th>Design component</th>
<th>Unit</th>
<th>Wemmershoek design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary treatment</td>
<td>-</td>
<td>Screening and grit removal</td>
</tr>
<tr>
<td>Secondary treatment</td>
<td>-</td>
<td>1 x 600 m³ Nereda® Influent Buffer 2 x 1 800 m³ Nereda® reactors</td>
</tr>
<tr>
<td>Tertiary treatment</td>
<td>-</td>
<td>Chlorine disinfection, maturation pond</td>
</tr>
<tr>
<td>Sludge treatment</td>
<td>-</td>
<td>Mechanical thickening and dewatering</td>
</tr>
<tr>
<td>Average Dry Weather Flow</td>
<td>Mℓ/ℓd</td>
<td>5</td>
</tr>
<tr>
<td>Peak Wet Weather Flow</td>
<td>Mℓ/ℓd</td>
<td>14.4</td>
</tr>
<tr>
<td>Effluent discharge</td>
<td>-</td>
<td>Discharge to Berg River and reuse for irrigation (pumped to Franschhoek)</td>
</tr>
<tr>
<td>Influent characteristics</td>
<td>-</td>
<td>Design (actual)</td>
</tr>
<tr>
<td>COD</td>
<td>mgCOD/ℓ</td>
<td>870 (796)</td>
</tr>
<tr>
<td>Total Kjeldahl nitrogen</td>
<td>mgTKN-N/ℓ</td>
<td>60</td>
</tr>
<tr>
<td>Ammonium</td>
<td>mgNH₄-N/ℓ</td>
<td>45 (79)</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mgNO₃-N/ℓ</td>
<td>-</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>mgP/ℓ</td>
<td>12 (11.7)</td>
</tr>
<tr>
<td>Ortho-phosphate</td>
<td>mgPO₄-P/ℓ</td>
<td>- (8.6)</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>mgTSS/ℓ</td>
<td>- (381)</td>
</tr>
</tbody>
</table>
removal. If optimal Nereda® biological phosphorus removal is implemented, effluent ortho-phosphate concentrations below 0.9 mgPO₄-P/ℓ could be achieved without chemical dosing (concentrations of 1.5 mg/ℓ, 0.6 mg/ℓ and 1.2 mg/ℓ were achieved during March 2015, giving a clear indication of the potential).

The Berg River Improvement Plan (BRIP) was developed in 2012 by the Western Cape provincial government, the Department of Water Affairs and local stakeholders. The main aims of the BRIP are the sound management of this sensitive catchment and the improvement of water quality. The Wemmershoek WWTP project is positively contributing to achieving the BRIP’s goals by limiting pollution loads from the Franschhoek area. This is an example of how innovative wastewater treatment solutions (Nereda®), in conjunction with exceptional municipal operations and management (Stellenbosch Municipality), can fit into broader integrated water resource management, as envisaged by South Africa’s National Water Act (2008).

LOOKING TOWARDS THE FUTURE

In February 2015, WEC Projects won a design-build tender to provide a 5 Mℓ/d capacity improvement at ERWAT’s Hartebeesfontein WWTP (Ekurhuleni). Royal HaskoningDHV will provide their Nereda® technology to WEC for the project, which primarily comprises the conversion of two existing, disused tanks into a Nereda® influent buffer tank (1 700 m³) and Nereda® reactor (2 900 m³) capable of treating 5 Mℓ/d. This project shows the versatility of Nereda®, and all involved stakeholders are excited about the imminent delivery of the first Nereda® in Gauteng via the cost-effective conversion of two existing tanks.

Global strategic planning is currently being redirected by sustainability issues which are necessitated by environmental and societal demands to adapt to key challenges such as energy generation and provision, water scarcity and global warming. Furthermore, the wastewater treatment industry in South Africa is facing numerous challenges, including stringent effluent requirements to safeguard water resources, a funding shortfall for capacity expansion and operations, ageing treatment infrastructure, as well as pressure to adapt towards sustainability goals such as effluent reuse and limiting energy usage for treatment. Nereda® is a proven, innovative and robust wastewater treatment technology that is ready for further widespread roll-out as a means to reduce capital and operational costs, and meet sustainability targets such as reducing energy usage, whilst achieving excellent effluent quality – indeed a solution to address the challenges facing the wastewater treatment industry.

The wastewater treatment industry in South Africa is facing numerous challenges, including stringent effluent requirements to safeguard water resources, a funding shortfall for capacity expansion and operations, ageing treatment infrastructure, as well as pressure to adapt towards sustainability goals such as effluent reuse and limiting energy usage for treatment.

Table 4: Effluent quality at Wemmershoek WWTP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average CSIR lab results - final effluent</th>
<th>Effluent requirement (general limit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>48.0</td>
<td>&lt; 75</td>
</tr>
<tr>
<td>Ammonium</td>
<td>0.3</td>
<td>&lt; 6</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0.1</td>
<td>&lt; 15</td>
</tr>
<tr>
<td>Nitrite</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>2.6</td>
<td>-</td>
</tr>
<tr>
<td>Ortho-phosphate</td>
<td>2.3</td>
<td>&lt; 10</td>
</tr>
</tbody>
</table>

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Improving the utilisation of the Lesotho Highlands Water Project whilst deepening international cooperation

**BACKGROUND**

The signing of the Lesotho Highlands Water Project (LHWP) Treaty between the governments of the Republic of South Africa and Lesotho on 24 October 1986 heralded the start of the largest international water project yet undertaken in southern Africa.

The first phase, completed in 2004, comprised two large dams at Katse and Mohale in Lesotho, a river diversion works at Matsoku and an extensive tunnel system to collect the water into the Katse Dam and convey it further to the Ash River in South Africa. On the way hydroelectric power is generated at Muela in Lesotho. Already in the treaty a number of further phases were foreseen. A feasibility study for the second phase (LHWP II),

![Figure 1: Integrated Vaal-Orange River System: high-level schematic diagram](image-url)
undertaken under the auspices of the Lesotho Highlands Water Commission, started in 2005 and was essentially completed in 2008 at a cost of R60 million equally divided between South Africa and Lesotho. It recommended the building of a large dam at Polihali in Lesotho with connecting tunnels to the Katse Dam. This would initially add a 153 million m³/annum yield at 98% reliability until a replacement dam is built to safeguard the supplies to the users from the Orange River. Thereafter the abstraction from the Polihali Dam could be increased to 437 million m³/annum.

The LHWP II recommendation culminated in an agreement in August 2011, ratified by South Africa in 2012, while Lesotho finalised its ratification process in 2013.

Early in 2015 Lesotho’s Ministry of Foreign Affairs and International Relations announced that Lesotho and South Africa were due to start the second phase of the LHWP at the end of March 2015. At that stage it was clear that the initial target date for completion of 2020 was in jeopardy.

Already at the 2012 World Water Forum in Marseille, France, senior Eskom and Sasol managers warned that the period until 2020, when Phase II of the LHWP would start to deliver water to the Vaal, was one of major risk – a drought during this period could have severe implications for these strategic industries, as well as other large industrial water users, agriculture and municipalities located in and around the country's economic heartland, Gauteng. With slippage in the programme of construction these concerns would have increased. However, improving the operation of the LHWP could make a crucial difference in the ability of South Africa to mitigate the effects of a severe drought.

**CURRENT OPERATION OF THE LHWP AND HYDROPOWER**

Water is supplied to South Africa from Lesotho according to the prescriptions of the Treaty. A specified quantity of water is released each year through the tunnels to the Vaal Dam, irrespective of the state of storage in the Vaal River System. This arrangement is primarily to suit the requirements of Lesotho to generate power at their 80 MW underground hydroelectric plant at Muela in the Butha-Buthe district. It should be noted that, from the definition in the Treaty of “Project” and the description of its purpose, the LHWP is firstly a water transfer project. Lesotho is, in addition, allowed to use such water transfers to generate power. The water transfer emphasis was also reflected in the apportionment of the project costs, where South Africa carried all costs pertaining to the water transfer project and Lesotho paid only for the additional costs for power generation.

Prior to the opening of the Muela hydroelectric power station in September 1998, as part of Phase 1A of the LHWP, all power to Lesotho was supplied by Eskom from South Africa. The electricity production at Muela ended Lesotho’s previous dependence, and even resulted in Lesotho becoming self-sufficient in electric power for a number of years. Later, due to the growth of Lesotho, the country again became reliant on Eskom to meet their peak power requirements, which had shown steady growth and exceeded 110 MW by 2006.

By 2010 Lesotho regularly exceeded its Notified Maximum Demand of 24 MW from South Africa. The unplanned additional load resulted in insecure supplies to the country.

**LHWP II AND HYDROPOWER**

The feasibility study of the LHWP II assessed opportunities, presented by this phase, to generate additional hydropower. One of the options entailed enlarging the existing Muela Power Station and linking it with a tunnel directly from Polihali Dam.

A direct (and longer) tunnel route from Polihali Dam to the existing Muela Power Station was found not viable in the...
feasibility study. However, Lesotho separately undertook further investigations in 2009 and came to the conclusion that they favoured this option, including a doubling of the power station from 80 MW to 160 MW (nominal output). The outages experienced by Lesotho, in addition to a desire for power-independence, arguably motivated their decision to invest R2.5 billion into this option.

South Africa was informed of Lesotho’s preference in September 2009, and that they required the full yield of Polihali Dam to go through the turbines following the operating logic of the Treaty. This requirement made the water resource planners of South Africa uneasy, as it ran counter to the general principle in systems operation to keep water in the higher level storages for as long as possible. This is so that the space in the lower dams can be utilised to catch floods that occur from the catchments in-between, i.e. below the upper dams. In addition, evaporation is generally lower in higher-lying regions. This is certainly the case here. Not only is the evaporation much higher at the Gariep and Vaal Dams than in the Lesotho Highlands, but these lower dams, being much flatter, have much larger surface areas exposed to evaporation for the same volume of water stored. To be kept in mind, too, was that the total storage of the LHWP after construction of Polihali Dam would be huge – more than three times Mean Annual Runoff (MAR) storage to be available so that it would take a considerable period to fill.

To understand the implications fully, South Africa undertook a detailed systems analysis.
SYSTEMS ANALYSIS AND IMPLICATIONS OF EXTENSION OF HYDROPOWER FACILITY

Subsequent to the negotiation of the Treaty, significant advances were made in the methodology used to analyse complex water resource systems. Tools developed in South Africa took into consideration the different levels of assurance required by different user sectors, growth in demands, and the imposition of restrictions to ride out droughts. Modern systems modelling methodology enables the water resource manager to analyse complete systems; instead of looking at the Vaal, the LHWP and the Orange separately, systems could be combined and analysed in an integrated manner.

To examine the Lesotho preferred option the LHWP and the Vaal Systems were linked. The high-level schematic in Figure 1 shows the complexity of the system.

A number of operational scenarios were analysed. Two scenarios are shown in Figure 2 (note that Polihali Dam was scheduled for completion in 2020 and the replacement dam in 2022).

In the first scenario, flow through turbines was phased in over two years, after which the full yield of LHWP II is passed through. This was Lesotho’s preference and called the “Block Delivery”. In the second scenario, flow through turbines took place in accordance with the actual requirement of the Vaal System, and kept in mind capacity limitations of the tunnels. This was called the “Variable Delivery”. This Variable Delivery scenario meant that the full Phase I transfer still took place to the Vaal, but the Phase II yield was held back in the Polihali Dam and only transferred as and when the Vaal required it.

When shortages of water supply are experienced, users have to be restricted. Depending on the severity of the restriction this can have severe social and economic impacts. Targeted assurance levels for the different user sectors in the Vaal System were set according to their varying characteristics and their ability to withstand different severities of restrictions. The likelihood that restrictions will be imposed was assessed for each of the operating scenarios. In Figures 3 and 4 the red colouring shows where risk criteria are violated.

The Block Delivery rule results in almost continuous violations of the risk criteria over the period of analysis. The Variable Delivery rule shows a violation shortly before the Polihali Dam comes on stream and then again after 2045. From a water delivery perspective this rule is superior – it gives the lowest risk of restrictions.

The results of the systems analysis showed that the Block Delivery rule would have destroyed any water resource benefit the LHWP II held for South Africa. These results were so convincing that Lesotho decided to abandon their plans to double the Muela hydroelectric plant. The outlay, as proposed in the feasibility study, was accepted by the two governments and formed the basis of the agreement signed.

FURTHER ANALYSES

The above results indicated a need for further studies to optimise the current transfer rule. A preliminary analysis entailed applying the Variable Delivery rule to the whole project, i.e. the LHWP I as current and after 2020 the scheme enlarged with LHWP II. The impact on the users in the Orange Basin, as well as the Vaal Basin, was examined and the results are shown in Figures 5 and 6 respectively.

The graphs in Figures 5 and 6 show a marked reduction in risk in the Vaal System in the period prior to the Polihali Dam coming on stream, and also that a further phase to augment the Vaal System would only be required round 2050. With regard to the Orange
System, the replacement dam will only be required to be in place after 2030. This is a result of the fact that the excess water held back in the LHWP dams and not utilised for the Vaal – when the Vaal does not require it – could be used rather in support of the Orange System.

CONCLUSIONS
With the delays in the construction of the Polihali Dam the concerns for shortages in the Vaal System in the next number of years are growing. Systems analyses have shown that a flexible operating rule, one that changes over time based on the short-term balance between available yield and the water requirements in a particular year, can markedly reduce the risk of curtailments. Little time is left to come to an arrangement regarding a revised rule to be implemented for the next number of years, and this needs to start as soon as possible. This will require keeping the Katse and Mohale Dams as full as possible, for as long as possible.

To come to such an arrangement South Africa will need to assure Lesotho that it will not be adversely affected, in particular with regard to assurances of electricity supplies and royalty income.

Although not of the same urgency, the two countries also need to agree on a longer-term operating rule for the enlarged project. It has been demonstrated that a flexible operating rule holds significant benefits as opposed to the Treaty operating rule currently in place. With a water-energy linked arrangement between the two countries, cooperation will be deepened even further, which will benefit both parties in the future.

Figure 5: Restrictions to the Orange System with Variable Delivery rule applied to both LHWP I and LHWP II

Figure 6: Restrictions to the Vaal System with Variable Delivery rule applied to both LHWP I and LHWP II
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CAREER-ENHANCING SHORT COURSES

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THE SWAZILAND WATER SERVICES Corporation awarded Inyatsi Construction a tender to construct a Wastewater Treatment Plant and Outfall Sewer located on the outskirts of Matsapha in Swaziland. When operational, this plant had to be able to process up to 20 Mℓ of wastewater per day. Practical completion was awarded in September 2014.

The scope of works involved the construction of 7.5 km of pipeline connecting the existing sewerage network to the new plant. The pipes were precast concrete pipes, spigot and socket 75d class and 100d class, depending on the depth of the pipeline. The diameters varied from 450 mm to 900 mm. Various watertight structures were constructed at the plant – from the complex inlet works to the 20 Mℓ biological reactor. Offices and dwellings for the future plant staff were also built, as well as the dewatering building and electrical rooms. The internal road network was constructed with interlocking pavers, and the 3.5 km access road was surfaced with a single-seal finish.

The challenges which were encountered generally revolved around the topography of the area. As this plant was to be gravity-fed from the existing sewer networks in Matsapha, it would have to maintain the necessary gradients for the
raw sewage to flow. As there was a climb in the ground level on the direct route between the existing sewer lines and the new treatment plant, the best way would have been to take the pipeline around this obstacle by following the geographical contours. However, the most direct route along the contour path was not possible, due to factories and warehouses in the already established industrial area. This meant that the only available routes pushed the pipeline closer to the swamplands surrounding the Lusushwana River. A significant portion of the proposed pipeline would have been inaccessible as a result. The solution was to construct a permanent access road adjacent to the pipeline, using dump rock, followed by a geotextile cloth, and finished with a compacted gravel layer. Trucks delivered rock to the edge of the path, and an excavator placed the rock in front of it, creating a rock bridge over the river. This allowed access to the pipeline route for construction, while also serving as a path for future service maintenance.

The success of this project, which was completed within budget and on time, can be attributed not only to the professional working relationships between the client, engineer and Inyatsi Construction, but also to the application of the principles of QCD – Quality (do it right the first time), Control (control every last little detail of every action to ensure that it is done right the first time) and Discipline (to continuously do this every time and in everything).

The construction of this plant has eliminated the need for the ponds which were being used for treatment, but which were no longer adequate because of the ever growing industrial area in Matsapha. This new plant will also ensure that downstream communities will not be subjected to environmentally unacceptable effluent discharged into the river. The size of the new plant will furthermore enable the construction of the Ezulwini Sewerage works, which will cater for the continued growth of the entire area. This is an important development area in Swaziland, boasting various hotels, shopping centres, offices, residential areas and other ongoing developments, two of which are the construction of an International Convention Centre and a five-star hotel (Inyatsi Construction is involved in both these contracts).
FORMATION OF SANCOLD
The South African National Committee on Large Dams (SANCOLD) was formed in 1965 when it joined the International Commission on Large Dams (ICOLD). At that stage there were only 45 member countries in ICOLD compared to the current 97, and six African Member countries compared to the 22 at present. When joining ICOLD, the proposed National Committee must form the organisation and prepare a constitution, as well as submit a register of its large dams, generally defined as having a height of more than 15 m. The current Register of South African Large Dams is on the SANCOLD website. The original initiative to form SANCOLD was driven by the then Department of Water Affairs. It is interesting to note that the SAICE Water Engineering Division also celebrates its 50th anniversary this year (see page 70). Over the years there has been close collaboration between the two bodies.

SAICE has a reserved position on the SANCOLD Management Committee, the current representative being Dr Eduard Vorster from the Geotechnical Division, with Tente Tente from the Water Engineering Division as the alternate.

SANCOLD GOVERNANCE STRUCTURES
The structure of the original SANCOLD Management Committee was on a corporate basis, with representatives being nominated by organisations such as the Department of Water Affairs (DWA), SAICE, SAFCEC, CESA, Universities and IMESA. The dominant organisation was the DWA. The focus of SANCOLD in the early years was more on international activities rather than local ones.

The organisation underwent a major change in governance in 2008 and is now based on a more democratic and representative structure. Details and the constitution are on the website. SANCOLD currently has 52 Corporate Members and 191 Individual Members. Paid-up members receive a membership certificate for the year in question. Membership benefits include significant discount for the attendance of the Annual SANCOLD Conference/Course and access to free ICOLD publications. In addition SANCOLD is now recognised as a Voluntary Association with ECSA, which gives members credits for ECSA fee reduction and CPD points. SANCOLD’s current activities are now directed to a balance between international and local activities.

SANCOLD PERSONALITIES
A number of prominent persons come to mind when looking at the history of SANCOLD. In the initial years the chairman was the Head of the Department of Water Affairs or the Secretary (now Director-General). The first chairman was Mr JM Jordaan, followed by Messrs JP Kriel and JG du Plessis. Thereafter the chairman was a senior member of the DWA, such as a Deputy Director-General. The incumbents were Drs Theo van Robbroeck and Paul Roberts.

In 2000, Rob Williamson of Knight Piésold was elected as chairman, and he was followed by Danie Badenhorst in 2010. This change of chairmanship from the DWA coincided with the increasing involvement of the private sector in dam engineering.

A large number of outstanding personalities in the engineering field were members of the SANCOLD Management Committee over the years. Names such as...
SANCOLD members have held high office within the ICOLD organisation, and ICOLD vice-presidents were Dr JP Kriel, Dr TPC van Robbroeck, Dr CPR Roberts and Dr GR Basson, with Dr van Robbroeck also serving as ICOLD president from 1994 to 1997.

ICOLD currently has some 25 Technical Committees with international membership. South Africa has chaired a number of these Committees which have produced valuable publications, known as ICOLD Bulletins. These publications reflect the state of the art in the various disciplines.

**SANCOLD ACTIVITIES OVER THE YEARS**

The initial years of SANCOLD’s existence were focused on ICOLD activities, such as providing information for the various Technical Committees. In 1978 SANCOLD hosted an ICOLD Executive Meeting in Cape Town. This was followed in 1994 when it hosted the Executive Meeting and Congress in Durban.

International delegates still remark on the 1994 event and the enjoyable time they had in South Africa! The Congress was opened by the newly elected President Nelson Mandela.

The most significant local event was the Symposium on Dam Safety in September 1986. ICOLD had been promoting the regulation of dam safety, and the exposure to international best practice had encouraged the Department of Water Affairs to promulgate dam safety legislation in July 1986. The Symposium was organised in collaboration with the then Hydraulics and Water Engineering Division of SAICE.

The organising committee members were CPR Roberts (Convener), A Rooseboom and WS Croucamp. Willie Croucamp became the Head of the DWA Dam Safety Office for many years and laid the sound foundation which we still have today. The Dam Safety Regulations were updated in 2012 in terms of the 1998 National Water Act, and no major changes were made to the original Regulations which have withstood the tests of time.

During the early 1990s SANCOLD produced several Guidelines on aspects such as floods and freeboard for dams. An initiative is currently under way to update these Guidelines. The Guideline on Freeboard for Dams was updated in 2011 in association with the University of Stellenbosch and the Water Research Commission. The Guideline on Floods is a large exercise, and SANCOLD has proposed a National Flood Study Programme to the Water Research Commission which will cost some R28 million. About 40 years of flood data needs to be included in the revised analysis, in addition to new flood methodology.

SANCOLD, in association with the Department of Civil Engineering of the University of Stellenbosch, ran a number of well attended courses and conferences so far in this century. Since 2014, SANCOLD has been responsible for the logistical arrangements in connection with the Annual Conference. Further details on the current activities of SANCOLD are on its website (www.sancold.org.za).

**SANCOLD: THE FUTURE**

SANCOLD has an ambitious programme of activities for the future, and these activity items are mentioned on the website. Two main future activities are:

- **SANCOLD Annual Conference, 1–3 September 2015, Cape Town**
- **ICOLD Annual Meeting, May 2016, Johannesburg.**

The general theme of the SANCOLD Annual Conference 2015 is *Dam safety, maintenance and rehabilitation of dams in Southern Africa.* Two tour options are being offered, namely:

- Clanwilliam Dam raising and Bulshoek Dam rehabilitation, or
- Visit to the historic Table Mountain dams where significant rehabilitation work was undertaken.

Arrangements for the organisation of the ICOLD Annual Meeting in 2016 in Johannesburg are in full swing. We will be attending the forthcoming ICOLD Meeting and Congress in Norway to encourage attendance in 2016. Our logo for 2016 is shown below and reflects the linkage between water and gold, which were so important to our economy in the early years of industrialisation. It is rather appropriate that the selection of this gold–water linkage coincides with our golden anniversary!

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INTRODUCTION

SAICE’s Water Engineering Division celebrated its 50th anniversary during National Water Week on 20 March 2015. The stylish event was attended by the who’s who in the industry and was held at the Johannesburg Country Club in Auckland Park.

Entertainer and comedian Conrad Koch, with his ventriloquist dummy Chester Missing, were the masters of ceremonies for the evening. Special guest speaker, Neil Macleod, gave an insightful presentation, titled Looking back 40 years and imagining the next 40 years – where will we be in 2055? The presentation was based on his 40-year career with the eThekwini Municipality, and highlighted various innovations and technologies over the past four decades. He also gave the audience a glimpse into what we could expect to see in 2055.

Kevin Pillay, current chairman of SAICE’s Water Engineering Division, said: “I am honoured to hold office in this milestone year, and to join the illustrious group of past Water Engineering Division chairpersons and water sector engineering practitioners.” He also paid tribute to South Africa’s competent engineering practitioners, saying that we can pride ourselves in having some of the world’s leading water specialists.

HISTORY OF THE DIVISION

The March 1964 issue of The Civil Engineer in South Africa (what is now Civil Engineering) stated that, in the Institution’s 1960 annual report, mention had been made of the need for an organisation to represent South Africa on bodies such as the International Water Supply Association. “The Council has now decided to proceed with the formation of a Division of Hydraulic
Civil Engineering, and a sub-committee has therefore been formed to draft the rules of procedure, etc.”

In January 1965 the first Divisional Committee of Hydraulic Engineering was established with ERP Chunnett as the chairman, JR Daymondas vice-chairman and LW Fourie as secretary. Other committee members included EL Baylis, R Immelman, RJ Laburn, Prof DC Midgley, RIDM Myburgh and PR Sanderson.

In 1965 the first newsletter of the new division highlighted the vital need for such a division: “For some time there has been a feeling in the Council that the formation of a special division could do much more to promote activity in the field of hydraulic engineering within the Institution. Matters of specific interest to hydraulic engineers tended to be overlooked in the whirl of general business, and it was left to a few individuals to struggle on without the benefit of a recognised body to back them up. There was no forum where water and water engineering problems could be thoroughly discussed and definite lines of action planned by the persons concerned.”

With the establishment of this division an important deficiency in the Institution’s framework had been made good. On 23 March 1965 an inauguration event was held, where the then president of SAICE, Thomas Watermeyer, said: “This evening we inaugurate the Division of Hydraulic Engineering. Its formation is warmly welcomed by the Institution, not only because of the vital importance of hydraulic engineering in the affairs of our country, but also because the establishment of this division completes the basic structure of our technical activities.”

MEMBERSHIP
The annual report of the division for 1965 reported that, during the first full year of the division’s existence, its membership reached the 220 mark. Today in 2015 the division has 1 630 members, making it one of SAICE’s largest divisions.

A COMMEMORATIVE PUBLICATION
To commemorate its 50th anniversary, the division produced a publication titled Celebrating 50 years of SAICE’s Water Engineering Division – 1965 to 2015.

This book includes messages from past chairpersons of the division, while the main section is dedicated to milestones from 1964 to the present, covering outstanding individuals, projects, technologies and events throughout this time. Articles by industry specialists are also included.

Putting the book together, and seeing the many one-of-a-kind and world-first technologies and projects that had achieved success and recognition over the years, was a remarkable learning experience, and made one appreciate again that we have a lot to be proud of in our South African water engineering history!

IN CLOSING
This occasion indeed offered the ideal opportunity to pay tribute to those civil engineers who have over the years served under the SAICE Water Engineering Division. In the spirit of the Institution as a voluntary association, the Division’s committee members are all volunteers who offer their time and expertise to benefit and give back to fellow SAICE members.
How low can you go?
How much can you reduce your household service costs?

This article is the fifth in a series on the economic pricing of services and the beneficial effect this could have on the economy and the everyday lives of people. The first four articles appeared in the October 2014, November 2014, March 2015 and April 2015 editions of Civil Engineering.

INTRODUCING SUSTAINABILITY
As a household you will receive all manner of suggestions on how to go off grid, put in a solar geyser and ultimately, if you are to follow the advice of the Bill and Melinda Gates Foundation, get rid of the flush toilet.

However, what might be appropriate for the single household might not be appropriate for Government’s objective of trying to develop financially and environmentally sustainable cities.

In this article the author will draw from his own household experience to demonstrate how concentrating on one service can lead to the wrong decisions in developing a sustainable city.

During the late 1990s and early 2000s the author was working extensively in low-income communities and became interested in how to reduce the cost of services as much as possible. Working on a single house on a 496 m² property in what is regarded the inner city of Johannesburg, he managed to reduce its monthly household service bill from R2 860 to R1 720 (in 2015 prices), while maintaining the same quality of service. This was achieved through good insulation (for both summer and winter), ventilation of the roof space, installation of a solar geyser, rainwater harvesting, and demonstrating through the use of greywater recycling and the use of a dry toilet that it was possible to disconnect from the municipal sewer.

If this were done for an RDP house the savings would be even more significant, as rates are not payable on the first R200 000 (see page 73 for the cost comparisons). It would thus appear that it would be a complete no-brainer to install all of these technologies. The author has in fact often been called on to give support to alternatives to flush toilets which, to the surprise of many, he has refused to do, as dry sanitation and solar geysers are only appropriate for particular circumstances. But why?

The cost of services as they appear on the municipal bill does not represent the full cost to the household – transport to the socio-economic hubs must be factored in as well. For example, a single breadwinner in a household travelling from Vlakfontein (next to the Ennerdale toll plaza) to Yeoville will take two taxis at a total cost of R66 per day. If the Vlakfontein to Johannesburg Central trip can be eliminated this could result in a saving of R54 per day (R1 134 per month). This saving is significantly more than the R261 per month for waterborne sewage. What is interesting is that whilst transport costs, often factoring it into their spending calculations, richer households are often oblivious as to how transport costs add to their monthly expenses and how they could curtail them if so desired.

HIGH-DENSITY LIVING OR LOW-DENSITY LIVING?
Since space in central Johannesburg is limited, the choice for the household is either to live in a single house on a sufficiently large stand to utilise all of these technologies. The author has in fact often been called on to give support to alternatives to flush toilets which, to the surprise of many, he has refused to do, as dry sanitation and solar geysers are only appropriate for particular circumstances. But why?

The cost of services as they appear on the municipal bill does not represent the full cost to the household – transport to the socio-economic hubs must be factored in as well. For example, a single breadwinner in a household travelling from Vlakfontein (next to the Ennerdale toll plaza) to Yeoville will take two taxis at a total cost of R66 per day. If the Vlakfontein to Johannesburg Central trip can be eliminated this could result in a saving of R54 per day (R1 134 per month). This saving is significantly more than the R261 per month for waterborne sewage. What is interesting is that whilst low-income households are acutely aware of transport costs, often factoring it into their spending calculations, richer households are often oblivious as to how transport costs add to their monthly expenses and how they could curtail them if so desired.

The first casualty of this move into central Johannesburg will be the dry toilet and the greywater recycling, as there will no longer be sufficient garden space to utilise the greywater and space to compost the faeces. Although the Bill and Melinda Gates Foundation have launched a campaign to reinvent the toilet, they have not been able to answer the often-asked question of how the greywater will be treated and transported away if no sewers are provided. If it makes the most economic sense to pipe water in then the same logic would apply.

This series of articles is presented in the author’s personal capacity and does not reflect the views of his employer.
**Table 1:** Cost of services pre-conversion at current City of Johannesburg municipal tariffs for a four-adult household residing at 48 Natal Street, Bellevue East, a 496 m² stand.

<table>
<thead>
<tr>
<th>Service</th>
<th>Average consumption</th>
<th>Amount incl VAT (Rand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>23 m³</td>
<td>228.29</td>
</tr>
<tr>
<td>Electricity</td>
<td>870 kWh</td>
<td>1 377.47</td>
</tr>
<tr>
<td>Egoli gas</td>
<td>0.1 GJ</td>
<td>129.28</td>
</tr>
<tr>
<td>Sewer</td>
<td></td>
<td>261.95</td>
</tr>
<tr>
<td>Refuse</td>
<td></td>
<td>112.85</td>
</tr>
<tr>
<td>General rates</td>
<td></td>
<td>143.76</td>
</tr>
<tr>
<td>Bottled gas</td>
<td>1 x 48 kg bottle every two months plus 4 x 9 kg bottles for heating during winter</td>
<td>607.20</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td><strong>R2 860.79</strong></td>
</tr>
</tbody>
</table>

**Table 2:** Cost of services post-conversion with a monthly read meter for 48 Natal Street.

<table>
<thead>
<tr>
<th>Service</th>
<th>Average consumption</th>
<th>Amount incl VAT (Rand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>15 m³</td>
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</tr>
<tr>
<td>Electricity</td>
<td>490 kWh</td>
<td>928.42</td>
</tr>
<tr>
<td>Egoli gas</td>
<td>0.1 GJ</td>
<td>129.28</td>
</tr>
<tr>
<td>Sewer</td>
<td></td>
<td>261.95</td>
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</tr>
<tr>
<td>General rates</td>
<td></td>
<td>143.76</td>
</tr>
<tr>
<td>Bottled gas</td>
<td>4 x 9 kg bottles for heating during winter</td>
<td>60.00</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td><strong>R1 721.27</strong></td>
</tr>
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Saving per month comparing Tables 1 and 2: **R 1 139.52**

Saving per year: **R 13 674.25**

**Table 3:** Cost of services post-conversion at current consumption with a prepaid meter for 48 Natal Street.

<table>
<thead>
<tr>
<th>Service</th>
<th>Average consumption</th>
<th>Amount incl VAT (Rand)</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
<td>15 m³</td>
<td>85.01</td>
</tr>
<tr>
<td>Electricity</td>
<td>490 kWh</td>
<td>526.54</td>
</tr>
<tr>
<td>Egoli gas</td>
<td>0.1 GJ</td>
<td>129.28</td>
</tr>
<tr>
<td>Sewer</td>
<td></td>
<td>261.95</td>
</tr>
<tr>
<td>Refuse</td>
<td></td>
<td>128.65</td>
</tr>
<tr>
<td>General rates</td>
<td></td>
<td>143.76</td>
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<tr>
<td>Bottled gas</td>
<td></td>
<td>60.00</td>
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<tr>
<td><strong>Total cost</strong></td>
<td></td>
<td><strong>R1 335.18</strong></td>
</tr>
</tbody>
</table>

Saving per month comparing Tables 1 and 3: **R1 525.61**

Saving per year: **R 18 307.32**

**Table 4:** Cost of services for an RDP house with no sewer connection, with a prepaid meter.

<table>
<thead>
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<th>Service</th>
<th>Average consumption</th>
<th>Amount incl VAT (Rand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>15 m³</td>
<td>85.01</td>
</tr>
<tr>
<td>Electricity</td>
<td>490 kWh</td>
<td>526.54</td>
</tr>
<tr>
<td>Egoli gas</td>
<td>0.1 GJ</td>
<td>129.28</td>
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<td>Sewer</td>
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<td>Refuse</td>
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<td>General rates</td>
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<tr>
<td>Bottled gas</td>
<td>4 x 9 kg bottles for heating during winter</td>
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</tr>
<tr>
<td><strong>Total cost</strong></td>
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<td><strong>R929.47</strong></td>
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Saving per month comparing Tables 1 and 4: **R1 931.32**

Saving per year: **R23 175.83**
Installing roof ventilation is one of the ways in which monthly household service bills can be reduced.

With greywater recycling it is possible to disconnect from the municipal sewer and save further on household costs.

A four-adult household residing at 48 Natal Street, Bellevue East, Johannesburg, on a 496 m² stand apply to taking the same water away. The only other method – using conservancy tanks and vacuum tankers – boggles the mind, due to the additional number of trucks that this would put on the road (along with all the attendant accidents and spills).

A further advantage of high-density living that is not often mentioned, is that the amount of water needed to flush a toilet decreases as the densities increase. This is because the water is required for two purposes: (1) to empty the toilet pan, and (2) to carry the waste, at minimum grade, to the point where other waste streams join. In a single house, such as the author’s, a flush of 5.5 litres is required to prevent blockages, but the same toilet installed in the flats next door would function on a flush of 4.5 litres.

The second, but not immediate casualty will be solar geysers. The limitation is the amount of roof space and the length of pipe from the roof to the apartments. Whilst solar geysers on high rise blocks of flats in Hillbrow would be an impossibility (at least for all the flats), it would be perfectly feasible to connect up all the flats in the three- to four-storey blocks in Yeoville (or even The Houghton on the Houghton Golf Course). Since these blocks of flats represent at least six times the original density of single occupancy stands this would go a long way to reducing transport costs and still keep service costs low.

THE SOLUTION

So, in answering the question of “How low can you go?” the answer for the nation as a whole, though not necessarily for the individual household, lies not in the more esoteric technologies such as dry sanitation, but in reducing a household’s transport costs by bringing people as close as possible to socio-economic opportunities.

Public policy should therefore be geared towards this objective of densifying the core, rather than building new single houses further and further out, and developing integrated public transport to ensure that car use in the densified areas does not increase (think of what is happening in the inner city of Johannesburg as a good example of where policy should be taking South Africa).

The question is how can South Africa accelerate this trend to get as low as possible?
Vacuvent has recently developed a smarter, more sophisticated anti-shock orifice for air release valves. Vacuvent’s new, smart anti-shock nozzle opens under pressure should a large bubble of air enter the air valve. This largely solves the problem of air entrapment and dynamically limits the outflow of air during all pipeline phases.

The anti-shock orifice uses the air already in the pipeline as an airbag to reduce water hammer. It does this by regulating the flow of air out of the valve, depending on the pressure at that point inside the pipeline. The valve keeps a pocket of air inside the pipeline until the water has slowed enough so as to not cause water hammer when the air valve finally closes, and has been developed to know when it’s filling, operating at full pressure or draining, so that the one valve will fulfil the function of many.

Figure 2 illustrates the fundamentals of how it works, assuming a 50 m head and no orifice. From Boyle’s law the air pocket will be 17% of the initial volume (curve B). When an orifice is fitted, some air is expelled during the filling cycle and curve C shows how the original 17% volume is reduced. If the orifice is too big most of the air will be lost (shown with curve D), so the final back pressure is too low to have any effect. The dotted line indicates the final back pressure as it crosses the 0 point vertical line.

Vacuvent’s design point is to get the final velocity towards the valve to almost zero (C), but still have some pressurised air to absorb the energy and dissipate the inertia of the water column by controlling the air release out of the anti-shock orifice – the smart part of the anti-shock orifice. If the orifice is too big, most of the initial air is lost and the final velocity is too high, with no slowing effect (curve D).

All Vacuvent valves have the large orifice closed by a bias spring – having some valves on the pipeline with large orifices open will lose this vital air during the critical filling stage. Even multi-stage valves which have a switch point to switch
the large orifice to anti-shock can be problematic, because if sized incorrectly there may be insufficient air pressure in the pipeline to employ this. This leaves the large orifice open, and high velocities before slamming shut. It is therefore almost impossible to try to determine the switch point for each position on the pipeline, and it is better to make sure the large orifices are always closed for venting. The final closing flow velocity has a direct influence on the induced pressure rise inside the pipeline.

A popular misconception is that keeping all the large orifices closed will slow down the filling rate, but that is not true on a few counts:

■ The presence of air in the pipeline means the designed friction loss is less than the full flow rate, so the initial flow will be higher given the same design energy (pumped or gravity).

■ The air volume is generally reduced as the pipeline starts to fill by compression.

■ Large orifices generally switch anyway at very low venting rates (3–5 kPa).

By having all large orifices biased closed during filling simply means the sufficient amount of air will be present in the valve for the smart anti-shock to absorb and dissipate that final energy. The Vacuvent air valve will always get rid of air inside the pipeline efficiently, as well as ensure faster pipeline filling and reduced water hammer. Provided the valve is sized for vacuum, the anti-shock will operate at any point in the pipeline profile.

Figure 2: Pressure variance of air flowing out through a small orifice

www.vacuentvalves.com

INFO
Clause 3.1.1 of the By-Laws reads as follows:
“Every candidate for election to the Council shall be a Corporate Member and shall be proposed by a Corporate Member and seconded by another Corporate Member.”

Nominees accepting nomination are required to sign opposite their names in the last column of the nomination form. Nomination for election to Council must be accompanied by a Curriculum Vitae of the nominee not exceeding 75 words. The CV will accompany the ballot form, and the format of the CV is described in Sections A and B. According to a 2004 Council resolution, candidates are requested to also submit a focus statement. Please see Section C in this regard.

Section A: Information concerning the nominee’s contribution to the Institution.
Section B: Information concerning nominee’s career, with special reference to civil engineering positions held, etc.
Section C: A brief statement of what the nominee intends to promote / achieve / stand for / introduce / contribute, or preferred area of interest.

Please Note: Nominations received without an attached CV will not be considered.
Closing date: 31 July 2015. Acceptable transmission formats – email, fax and ordinary mail. All nominations are treated with due respect of confidentiality.

If more than 10 nominees from Corporate Members are received, a ballot will have to be held. If a ballot is to be held, the closing date for the ballot will be 31 August 2015. Notice of the ballot will be sent out using two formats, i.e.
1 By e-mail to those Corporate Members whose electronic address appears on the SAICE database, and
2 By normal surface mail to those members who have not informed SAICE of an e-mail address.

M Pillay Pr Eng
Chief Executive Officer
April 2015

Please turn over for nomination form >>

TO ALL CORPORATE MEMBERS

NOMINATIONS FOR ELECTION OF
SAICE 2016 COUNCIL

THE SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERING - Nomination for election of Members of Council for the year 2016 in terms of Clause 3.1 of the By-Laws

In accordance with Clause 3.3 of the Constitution, the Council has elected Office Bearers for the Institution for 2016 as follows:

President          Dr C Herold
President-Elect    Mr S Naicker
Vice-President     Mr E Kerst
Vice-President     Mrs D Magugumela
Vice-President     Mr A Frieslaar
Vice-President     Mr E Chinnappen

In terms of Clause 3.3.4 of the Constitution, the following are ipso facto members of the Council for the year 2016:

The immediate Past-President  Mr M Pautz
The two most recent Past- Presidents  Mr S Mkhasane
                                             Mr P Kleynhans
### NOMINATION FORM 2016

#### 10 Corporate Members

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<th>PROPOSER</th>
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#### Under 36 Members

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Please fax, e-mail or post this form, plus the CV of the nominee, to SAICE National Office, for attention Memory Scheepers, by 31 July 2015

Fax: 011 805 5971 | e-mail: memory@saice.org.za | Postal address: Private Bag X200, Halfway House, 1685
# Candidate Academy Course Schedule 2015

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<th>Course Presenter</th>
<th>Contact</th>
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<td>Durban</td>
<td>CESA-357-04/2016</td>
<td>Allyson Lawless</td>
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<td>Road to Registration for Mature Candidates</td>
<td>5 October 2015</td>
<td>Cape Town</td>
<td>CESA-484-01/2017</td>
<td>Peter Coetzee</td>
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<td>CESA-359-04/2016</td>
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<td>14-16 October 2015</td>
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<td>Getting Acquainted with Road Construction and Maintenance</td>
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<td>CESA-379-05/2016</td>
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<td>Getting Acquainted with Basic Pressure Pipeline Design</td>
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<td>CESA-376-05/2016</td>
<td>Dup van Renen</td>
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<td>Cape Town</td>
<td>SAICEgeo14/01627/17</td>
<td>Edoardo Zannoni</td>
<td><a href="mailto:margie@ally.co.za">margie@ally.co.za</a></td>
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In-house courses are available. To arrange please contact Margie Rigby (margie@ally.co.za) on 011 476 4100.

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<td>4–5 November 2015</td>
<td>Bloemfontein</td>
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<td>Earthmoving Equipment, Technology and Management for Civil Engineering and Infrastructure Projects</td>
<td>22–24 July 2015</td>
<td>Midrand</td>
<td>SAICEcon12/01177/15</td>
<td>Prof Zvi Borowitsch</td>
<td><a href="mailto:dawn@saice.org.za">dawn@saice.org.za</a></td>
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In-house courses are available. To arrange, please contact: Cheryl-Lee Williams (cheryl-lee@saice.org.za) or Dawn Hermanus (dawn@saice.org.za) on 011 805 5947
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