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ON THE COVER

Dams play an important role in the development and management of South Africa’s water resources. This picture, taken in April 2011 by the secretary of SANCOLD, Dr Paul Roberts, is of the Beervlei Dam, a flood attenuation dam for the lower Gamtoos valley in the Eastern Cape. Read more about SANCOLD on page 66, and about the Algoa Water Supply System on page 34.

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FROM THE CEO’S DESK

Discount – a real steal!

A FEW YEARS AGO, I worked as an assistant resident engineer on a gold mine tailings dam construction site in Mali, West Africa. In the heart of Bamako, the capital city of Mali, there is a huge open market, partly under a dilapidated warehouse, where illegal gold, international currencies, branded clothing and shoes, vegetables, kitchenware and many more items are available for purchase.

The market is a hive of activity – throngs of people, traffic congestion, roaming animals and bustling trade. Shops are closely packed stalls, with goods dangling over wooden and metal frames. In this environment of cramped trading activity, where raucous crowds witness energetic negotiations over a purchase, trade without bargaining is unusual. Negotiation brings out the skill of the traders, and encourages verve in the market place.

This scenario, for better or for worse, is not unlike many other business negotiations the world over. The deplorable practice of price discounting in engineering comes to mind.

In the infrastructure engineering business, in the sale of professional services between engineers and clients, whether on a time and expense basis or percentage on capital expenditure basis, it is important to first appreciate the context of the sale. This includes the complex nature of identification and management of projects and the movement of funds for the project.

Very briefly, the client wishes to have the service and end product delivered at the cheapest cost, in the quickest time frame and at the highest quality. This is naturally acceptable in all forms of the trade model, i.e. achieve the highest profit or outcome after sales less cost of sale. But I want to explore the engineer’s perspective, and will discuss three components of the project cycle.

Project challenges and solutions are mainly identified in the prefeasibility and feasibility phases of the project, so it is fair to say that most cost savings are identified here. In this phase, creative and innovative solutions are recognised via the Environmental Impact Assessment process and often in the options analysis. It follows that discounting or reducing the cost of this phase has a detrimental risk on the overall project.

The detailed design phase requires the involvement of a range of engineering staff to ensure accuracy and completeness. As an example, a small project will require a senior professional engineer, two graduate engineers, a draughtsperson and an administrator. The senior engineer ensures quality management input, professional authenticity, and oversees professional indemnity issues. Graduate engineers do the actual work under the guidance of the senior engineer. Their tasks include, among others, doing the sketches, managing the drawing office, report-writing, generating schedules of quantities, and tender compilation. The administrator ensures that secretarial and basic accounting aspects of the project are carried out. It is also normal for the team to be working on more than one project at a time.

In the construction monitoring phase, depending on the type and magnitude of the project, it is necessary to have a senior engineer as a resident engineer (sometimes on a part-time basis), an assistant engineer, who is usually a graduate engineer, and a site foreman.

All phases of the project, including the ones described above, also have important elements of training and development, and quality management associated with them. On-the-project training for graduate professionals is critical for sustainable civil engineering in South Africa.

Price discounting creates havoc in the quality of work during all phases of the project cycle, and has further cost implications that become apparent only during the operation and maintenance phase of a project, after the consultant and construction teams are long gone. Discounting project fees in fact affects the overall delivery of a project more than the profit coffers of the service provider.

Clearly, discounting in the engineering business should not be a simplistic request. The client perceives a discount as receiving the same product or service for a cheaper rate. The reality, however, is that in offering reduced fees, critical steps in the project cycle are omitted, compromising the integrity of the project.

There is a chain effect of repercussions that eventually returns to bite the client and does more harm to the ultimate goal of service delivery. It is time that the client treats discounting with the same contempt as corruption, and stops treating the purchase of civil engineering services as though he is negotiating the sale of black market gold granules in the cramped quarters of a Bamako market.
Leadership and fun in the workplace

At the end of last year Richard Robertson resigned as Chairman of MBB Services International (MSI), but remains a director and shareholder of MBB Pietermaritzburg, and a shareholder of the holding company. For 24 years Richard helped to lead MBB Consulting Engineers, one of Africa’s largest agricultural engineering groups. Here he shares some of his leadership ideas with us.

DURING THE LAST QUARTER of a century I have had the opportunity to work with many wonderful people and put to work some rather unorthodox ideas, such as developing a company by developing people and promoting fun in the workplace. I also strongly believe in encouraging people to become leaders, especially today when every aspect of our lives in South Africa cries out for strong leadership.

The results have much to say about the power of managing people a little differently. Over the last few years MSI has performed markedly well given the global economic crisis, and remains stable, financially sound and strategically well placed.

About a year ago I realised it was time for me to hand over day to day management to the next generation and to refocus my life. This will include concentrating on the development of strategy skills, the growth of people as leaders, and performance management. Another part of this change is getting back to earth and building dams. I have had the privilege of being involved with the design and construction of over 250 dams – this is one of the greatest loves of my life.

A successful business depends on attracting decent, honest, hardworking, happy people. We employ the person before the engineer, because no matter how clever engineers are, if they cause friction among the team they are a liability. I am convinced that choosing the right people and developing them has been a significant factor in MSI’s success.

Major changes in MBB took place six to ten years ago with the birth of MBB Services International (MSI). The group was restructured into individual units, which became responsible for their own profits and losses. Managing Directors were appointed for each unit and shares were available, on an invitational basis, to local personnel. Effectively this put each unit at the coal face; they were responsible for everything from marketing to selecting the best personnel. Under this system there was simply no room to hide and units became effective and efficient.

Following these changes there was a settling down period of about a year before the benefits began to show. Our bottom line profits improved, overheads were trimmed and units became more streamlined. However, the really big changes have been in performance and quality of work, and also improved cooperation between units.

As a young engineer I learned a great deal from good and bad managers. Through this, and many learning experiences, a picture of how I would like a company to operate, developed. I wanted to make a difference in peoples’ lives by creating an organisation with quality staff who were happy in their careers and who could produce high quality work to a deadline.

In 1986 I opened MBB Pietermaritzburg and from the beginning we showed a profit through strict cost management. For the first two years jobs were hunted down and captured; then we became known and the first projects arrived unsolicited. Word of mouth about the quality of work produced by our team had begun to spread.

In a ‘light-bulb’ moment as a young manager I realised that management, excellent work, profitability and so much more was ‘all about the people’. If you can guide and manage the people, anything is achievable. While the concept might seem obvious, many managers fail to grasp its full importance.

This was a tremendously exciting realisation for me and brought a deep understanding of how vital people – their development and their happiness – are to the success of any business. People and their management became the cornerstone of MBB Consulting Engineers Pietermaritzburg. I think many companies ignore this concept to their extreme detriment.

Creating a relaxed, fun working environment is great in principle, but it is much more demanding to manage than simply ‘working to rule’. It calls for leadership more than traditional management, as attitudes can easily become slack with fun taking over from work. There must be a balance and I have been told I’m a rather hard taskmaster. It is also vital to identify and deal with non-performers or disruptive elements at an early stage. Retaining the right people is one of a manager’s most important roles.

The value of being happy at work is vastly underrated in business. I have repeatedly found a link between staff members’ state of mind – their level of enjoyment and stimulation at work – and their performance. If they love what they do they generally excel. An open, relaxed and trusting atmosphere benefits all aspects of a project, including its viability. This is true in any situation, including the relationship between the client and consultant, and of course the contractor.
At 42 I learned I had cancer and am grateful to have won the battle with the disease. At this crossroads in my life I did not worry about the work I had not done, or profit, or the latest design techniques – I worried about time with my family.

I cannot emphasise enough that people have lives outside the office and they must be allowed to enjoy events with their children. After the cancer I seldom missed a Wednesday afternoon cricket match or a speech day, whereas before I often did. However, freedom brings responsibility, the deadlines remain and quality demands must be met.

These principles will only work with people who have a high standard of ethics, a balanced perspective on life, are good at what they do and take pleasure in doing it.

While people are enjoying their jobs I expect them to work hard, be responsible and complete projects on time. In this atmosphere cooperation is essential and everyone is encouraged to help their colleagues have a better day. I much prefer the sound of laughter to raised voices in an office. Arguments are unacceptable as there is always a civilised way to debate differences of opinion. If someone has behaved badly a genuine apology is needed, followed by an acceptance of that apology.

I am passionate about developing leadership qualities in others, and although some people automatically gravitate towards leadership, the skills can be taught to the willing and interested.

Good leaders are easy to spot – they think of their team before they think of themselves. Senior positions do not mean entitlement or special privileges, but offer the privilege of helping to influence others’ lives for the better. Quality leaders do not need special parking spaces, fancy cars, massive salaries or the biggest offices to boost their egos. They are secure in themselves and see their role in much larger terms.

The best leaders are often the quiet ones – a leader does not have to hog the limelight or make rousing speeches, although many great leaders were great orators. Good leaders do not need to raise their voices, they do not rule by fear and they do not bully. It is easy for them to be generous as people tend not to take advantage of a person they respect.

Leadership defines the character of an organisation, and the quality and style of this leadership filters from the top down to the most junior employee. You can tell almost immediately which organisations have skilled leaders – they will be the successful ones, those that consistently deliver excellence, have a positive, ‘can do’ attitude, and the staff, at all levels, are helpful and friendly.

Many of South Africa’s leaders seem to hold the wrong idea about their roles. Someone who is purely politically motivated cannot effectively lead a nation. The country and the welfare of its people as a whole have to come first before any political agenda.

We have some great engineering companies and many great engineers in our country. Engineers tend to beat through the rubbish and get to the core of issues, and there is huge scope for this skill to be used outside the realm of engineering. I would like to see more of our senior engineers taking a greater role in solving society’s problems, spreading their influence and bringing their leadership qualities to areas that will benefit South Africa.

Richard Robertson
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Major water threats

**INTRODUCTION**

In 2008 the SAICE Water Engineering Division assembled a group of water specialists from a range of disciplines to prepare a submission to the Parliamentary Portfolio Committee on Water Affairs. The upshot was the pairing of the two words “water” and “crisis”, which have since become common coinage.

But is the sky really falling? Unless we take immediate remedial action, yes. But not in the way you might suppose.

The crises are discussed in ascending order of importance, ending with the one thought that poses the greatest threat.

**AMD (ACID MINE DRAINAGE)**

Think water crisis and the popular press conjures up images of a flood of acid mine water spreading ominously across the streets of Johannesburg, dissolving the foundations of high-rise buildings and rendering our water resources unfit for use. Just how serious a threat is this?

While this holds important consequences that cannot be ignored, it is nothing new. The total decant, which will be driven by rainwater recharge, will be lower than the peak dewatering of the deepening Witwatersrand gold mines that was experienced in the 1950s. Uncontrolled decant would contaminate some near surface aquifers which could otherwise have been used for irrigation wells. But the mine decant would emanate from the lowest lying mine shafts near to the surface drainage system.

If, as now seems likely, emergency measures are put in place in the nick of time, pumps will be installed low enough to prevent contamination of aquifers and the decant will then be pumped out at an old shaft. It will also be treated to neutralise and oxidise the water to remove metals. We will be left with the salinity, but this will not be much different from what we had when the mines were still operating, except that the overall discharge rate will be lower. It is therefore implausible that bridges and culverts that were designed to pass much bigger floods will be swamped by the increased base flow, especially since the older structures handled these flows in years gone by and newer structures tend to have bigger openings to accommodate increased urban runoff.

Now for the interesting part – in the bad old days much of the mine water discharge was not even treated! Hence discharge salt concentrations were significantly higher and at the points of discharge the water was acutely acidic and laden with unwholesome metals. Yet, within a few kilometres of the source the acidity had neutralised and the metals precipitated out. Another surprise to some is that after Sallies Gold Mine and Ergo (the last men standing in the area) stopped dewatering, the market gardeners along the Rietspriet moaned pitifully because they had been denied their source of irrigation water (at a tenth of the salinity of sea water!). How could they irrigate with that water? Well, the gold mine water is predominantly calcium-sulphate (gypsum) – the stuff that farmers apply to their lands to improve the drainage of their soils. Since the
soil drainage is kept open, all they have to do is irrigate with enough water to ensure sufficient leaching to prevent a salt build up.

Another plus factor is that, at over 310 million m³ p.a., the current diluting sewage effluent discharge is over six times more than it was in the late 1950s. Paved urban areas (and hence urban runoff) have also grown about four-fold. Hence the dilution factor is now much better than at the peak of the mining operations.

The clincher is that we can expect a steady improvement in the salinity of the decant water. Records at Grootvlei Gold Mine show a steady decline in salt concentration from about 3 600 mg/ℓ in 1995 to 2 000 mg/ℓ today (a 44% improvement in just 15 years). And the trend is still downwards. This is because once submerged, the pyrite-rich strata become starved of oxygen and the production of sulphate is drastically reduced. Oxygen can then only enter the workings via the rainfall ingress, which is a far cry from having two or three kilometres of operating workings open to the atmosphere. Much of the saline water is also trapped deep underground, where it belongs.

So, are we facing treacherous uncharted waters in the Klip and Vaal River catchment? Not unless you have a short memory. Been there – done that. In fact, the discharge will be less than in the past, the assimilative capacity is much larger (more dilution available), the water will be treated and the salinity will steadily improve. Even then we have the option to consider introducing desalination at a later stage, although this would be a very expensive option that would be hard to justify. (Think of how silly we would look if we blow lots of money on the capital works only to see the economic return diminish steadily as the salinity of the feed water improves all by itself.) So, while the salinity is still a force to be reckoned with and affects how we operate the Vaal River system, we are hardly facing anything new. So Chicken Little need not dive for cover.

What is new is the recent decant into the upper reaches of the Bloubankspruit. For the first time in 2002 a substantial quantity of saline mine water started spilling into the Crocodile River catchment. Sloppy decision-making amounting to failed brinkmanship has allowed the uncontrolled and untreated decant of acid mine drainage to the north. Aside from the severe local effects of acidity and high concentrations of metals, the approximately 32 000 t p.a. salt load is also considerable. Model studies showed that the salt concentrations at the DWA (Department of Water Affairs) monitoring station A2H049 further downstream on the Bloubankspruit could have been expected to increase from 400 mg/ℓ to 1 400 mg/ℓ. Even with all the diluting sewage discharge to the Crocodile River, the salt concentration of the runoff into Hartbeespoort Dam has been calculated to increase by about 100 mg/ℓ. Surprisingly there is not yet any evidence of any impact at A2H049. It is thought that most of the added salt load is entering dolomitic groundwater storage, complicated by groundwater irrigation abstractions. Presumably the salt load in the groundwater compartments might take a number of years before building up to a new equilibrium level and the full downstream effect materialises. This threat casts further doubt on the viability of the intended regional water purification plant at Hartbeespoort Dam.

**WATER QUALITY**

Poor sewage water treatment is undoubtedly a threat to safe water supplies and also results in the all too obvious eutrophication problems that we see in the Middle Vaal River and in Hartbeespoort Dam. Serious as they are, some of these problems are not unique. For example, eutrophication has been with us for many years and will no doubt present serious management challenges for decades to come. The sheer scale of the widespread collapse of sewage treatment is a new crisis that will take a great deal to rebuild. The underlying crumbling technical and managerial capacity, the associated loss of institutional memory and the absence of political will to use funds wisely (and sometimes honestly) are the underlying causes in most of the smaller local authorities. While still coping, some of the larger metros are also beginning to creak under the pressure, as are some of the larger Water Boards that supply them with water.

These crises are huge. But we face even bigger ones.

---

**WATER SUPPLY AND WATER DEMAND MISMATCH**

The Vaal River system is currently in deficit and this will worsen until delivery commences from the proposed Polhali Dam in Lesotho (Herold 2010). However, the current rise in water demand would mean that the increased capacity of the system would again be overtaken within just four years, after which Mielietuin Dam on the Mooi River would already have to be delivering water, followed not too long afterwards by Jana Dam on the Tugela River, which would about exhaust our reasonably available water resources. The Umgeni River system has been running in deficit for at least seven years and, even after the long overdue commissioning of Spring Grove Dam, would remain in deficit for the better part of another decade. Hence the water supplies to these two areas that generate the lion’s share of the GNP of our nation are at unacceptable risk.

An abnormally long run of good rains is all that is preventing us from facing water restrictions.

Is this the result of poor planning? No, it is not. DWA planners anticipated these problems several years ago. In part the problems arose from failure to implement new works (e.g. the delays in Spring Grove Dam). But it was also realised that the projected rapid depletion of our remaining available water resources is unsustainable. Consequently it was agreed that Water Demand Management and Water Conservation (WDM/WC) measures needed to be implemented. In the case of the Vaal River a 15% reduction in urban water demand was depended on to justify commissioning Polihale Dam by 2019. This was to have been achieved by reducing unacceptable water losses.

To date no discernable reduction in losses has been realised. It is understood that Johannesburg Water has a ten-year plan to work through their maintenance backlog that would cost R1 billion per year. This year their budget has been halved, due to billing problems, so the backlog (and the leakage loss) will grow even larger, rather than shrinking. Media reports indicate that most of the money granted to the municipality to address infrastructure backlogs will have to be used to fund deficits arising from their billing problems. If this is
The loss of technical and managerial capacity and the lack of political will are the underlying causes of most of the preceding crises. The loss by local authorities of six-sevenths of their engineering and technical skills goes a long way to explain the parlous state that they are in. Add to that the loss of managerial skills and a liberal dose of corruption and we have a recipe for disaster. DWA has a proud record of technical expertise and its role probably makes it our most technical government department, requiring 250 engineering posts. Alarmingly, in 2007 only 39% of these posts were filled. This is scary enough and has become increasingly evident in the high stress levels in skilled DWA staff, the long delays in getting out tenders, declining supervision of contracts and the number of balls that are being dropped (such as the water resource theft described in last year’s article (Herold 2010)).

EROSION OF CAPACITY
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In 2008 we were told that 47% of DWA’s remaining skilled engineers would retire within ten years. It therefore came as a shock to learn that by late last year the number of engineers had already declined to about 50, which means that the expected ten-year loss of half of the remaining skills has taken only four years! Much worse, the irreplaceable institutional memory of those leaving has not been passed on to new recruits, who are conspicuous by their absence. The persons who broached this matter did not exaggerate when they said: “We are running on fumes”.

This is potentially more damaging than all the preceding crises, since, if the DWA’s planning function fails, we will be running blind, and if the Department becomes impotent there will be no-one to hold the local authorities accountable.

You think that is bad? Now for the really big crisis that we didn’t even think was there three years ago.

CLIMATE CHANGE
Of course! This is the Joker in the pack that will soon gobble up a large chunk of our water resources, right? Wrong.

Climate change is our biggest threat for a very different reason.

In the SAICE submission to the Portfolio Committee on Water Affairs in 2008 climate change was placed right at the bottom of the list of crises and the statement was made that, “compared with the man-made crises that we are facing, climate change is still a much less imminent threat”. While nothing has happened since then to change this opinion, we made the strategic blunder of leaving the field open for others to run away with the agenda and push through radical changes that threaten to cripple our national economy. The reason is simple – we were all too busy trying to do something useful like addressing the more important issues.

On 10 March this year Professor Grant Cawthorn of the University of the Witwatersrand School of Geosciences was quoted in Mining Weekly (online: miningweekly.com) as stating that
“Climate change is probably the world’s biggest distraction.” Unfortunately this is an understatement. It is much more than a mere distraction. A feeding frenzy has already set in to divert a grotesque share of our scarce national resources to drastically slash carbon emissions (and incidentally directing hearty profits into the pockets of eager developers who would otherwise be unable to sell their hopelessly expensive technologies).

Right now we are in the early stages of a very steep hike in electricity costs due to the construction of just two long-overdue conventional coal-fired power stations, which happen to be the cheapest and most efficient option. We are sitting on about two-thirds of the coal reserves of Africa and the fabulous thick Waterberg coal seams alone can support nearly 20 new large power stations. Instead of using this largess, we are being urged to rush blindly in and throw everything into alternative energy sources, which are between two (wind) and three (solar) times more expensive than coal. (Think what that will do to your electricity bill and our pivotal industries.) In the meantime our cash-strapped municipalities cannot even afford to maintain their crumbling infrastructure, let alone expand it. Add to that the intention to introduce a carbon tax that would rake in R82 billion per year! This is equivalent to incurring the cost of building a new Medupi power station every 1.5 years – for decades to come! And don’t forget that Medupi power station is greatly over-priced since the tenders were let when our backs were to the wall and just before the over-heated world economic bubble burst. The only difference is that the carbon tax may not get us any new power stations for our money. Its main effect will be to push up the cost of electricity to astronomical levels, hammer our means of production and price our manufactured products out of the export markets. Employment targets will become pipe dreams and the hope of tens of millions of our people to escape from grinding poverty will be dashed.

Even if the hypothesis that anthropogenic carbon emissions are the main driver of climate change eventually proves correct, the timing is all wrong. Right now we need to utilise our cheap energy to drive economic growth, create jobs and restore and expand essential infrastructure. Rushing in far ahead of our competitors is a sure way to lose what is left of our export markets, which, once lost, would take decades to win back. The double-whammy is that the high cost of locally produced goods would mean that they would also lose ground to better priced imports. Job losses, or at the very least stagnation of growth, would seal the fate of millions of our people.

Does this sound like an exaggeration? Just compare R82 billion with the entire audited 2009/2010 tax revenue of just R580 billion and you will see what I mean. Last year we also over-spent our tax revenue by R168 billion (29%), with similar projected deficits for the next four tax years (National Treasury 2011). Another R82 billion onto that will not be pretty. It will help SARS to look good since it will be income for them, but it will be equivalent to a 14% increase in income tax for the rest of us since the tax will be passed on to all productive consumers who happen to pay their electricity bills. Moreover, the reduction in competitiveness is likely to put downward pressure on the GDP, which will magnify the impact of the tax. The large budget deficit also increases the risk that the carbon tax could be soaked up to reduce the budget deficit, which means that we would all have to pay a similar amount on top of the carbon tax to fund the doubling or trebling of the cost of new power generation plant. This will directly reduce our ability to fund essential maintenance, refurbishment and water infrastructure development. Naturally it would have a similar impact on all other forms of infrastructure development and betterment of society. Infrastructure bottlenecks would in turn further constrict manufacturing capacity and drag down our economy even further.

Of course some may take comfort in the thought that the ensuing economic decline will have the desired effect of reducing our carbon footprint.

The sad fact is that all this sacrifice will be pretty useless as it will hardly dent global carbon emissions. Moreover, other nations are eagerly queuing up to purchase our cheap coal so that they can burn it and remain more competitive than us. The most touted potential impact of climate change (and the one for which there is the least evidence) is that on water resources. Yet, if that were to occur (whether caused by anthropogenic carbon emissions or natural causes), we would be powerless to take mitigating measures if we had already foolishly run down our economy and blown our pay cheque trying to reduce emissions. Eventually we will need to wean ourselves off fossil fuels, but right now we have to do some serious building of our economy. Aside from meeting the pressing aspirations of our people, it will place us in a much stronger position to switch energy sources later when the time comes.

And for us that time is half a century or more away. Most of our competitors will run out of cheap fossil fuels long before we do (and make no mistake, they will continue to use them until that happens), which would give us a competitive advantage to build up our economy. It would also prevent us from losing markets when we eventually switch over. Another big advantage is that we won’t have to waste our meagre resources finding the best alternatives – the expensive learning curve would already have been carried by other nations better able than us to afford it. The key lies in the timing. And now is not the right time.

So the big immediate show-stopping threat of climate change is not the effect on climate. Rather it is the panic-stricken “sky is falling” mentality that would have us charge like lemmings off the lip of the nearest economic cliff.

It is not insignificant that in the same sentence quoted by Mining Weekly, Professor Cawthorn added that our “biggest and most immediate challenge ... belongs to clean water”. But then, how will we address this if we blow our financial resources chasing shadows?

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Will water finally make it onto the climate agenda in Durban?

Many of the impacts of climate change will be felt through water – but getting water and its management onto the climate change agenda has been an uphill battle. It is proving even more difficult to ensure that some of the copious resources that are going into the climate change business flow to the water sector to do something useful. But progress is slowly being made. With the climate negotiations coming to Durban at the end of this year, water resource managers and professionals must raise their voices and make their needs heard like malaria spreading where they had never been seen before, and water supplies in coastal areas rendered useless by salinisation caused by rising sea levels. And that was before the discussion of the agricultural impacts and food shortages expected as a result of changing rainfall.

As UN Secretary-General Ban Ki-moon summarised it: “The evidence assaults us: melting ice caps, advancing deserts, rising sea levels.”

Yet, in the final declaration, there was nothing about water. The word was not even mentioned.

Does this matter? Many water resource practitioners believe that climate change is not a high priority. But, as the 2010 report on Global Water Security from Britain’s Royal Academy of Engineers put it, “Water security is under severe pressure from many sources; a world population explosion, rapid shifts of people from rural to urban areas, the impact of dietary change as countries develop, increasing pollution of water resources, the over-abstraction of ground-water and the not insignificant issues created by climate change.”

The growing challenges faced by water managers today – growing demands, increased pollution, environmental protection – have to be managed in the context of an already highly variable climate. Preparing for relatively gradual climate change some time in the next few decades is not their top priority. However, you do not have to be a believer in climate change to support the calls for more attention to water management.

One consequence of the attention focused on climate change is that it diverts attention from the management of water resources. There are many practical indicators of this. There is a data drought in the sector. Much global water resource data – including the estimates of country water availability – have not been revised for years. Many countries have seen their hydrological networks decline and decay, not just in poor developing countries, but even in rich countries like the USA. When economic times are tough, water resource management budgets are often cut ahead of more immediate priorities like domestic water supply and health care.

It also matters when world leaders focus on developing responses to climate change and put big budgets into programmes to help societies “mitigate” the change and adapt to its effects. In many cases, these programmes are driven by climate experts who do not understand the sectors they work with and, as a result, divert attention from immediate priorities and more strategic responses.

Slowly this is changing, largely as the result of an active campaign by a coalition of water organisations, such as the Global Water Partnership and UN-Water, the coalition of the UN’s water-related agencies.

One mark of this progress came during last December’s climate meeting in
Cancun, Mexico. There, for the first time, some governments from developing countries raised concerns about the absence of water from the climate negotiations.

Ecuador called for water to be on the agenda for discussions about long-term adaptation initiatives to be held in 2011. Sudan backed their proposal, noting that, “Water-related climate effects are already being felt. 70 to 250 million people in Africa will be compromised by 2020. Crop yields will decrease by up to 50%. Almost 2/3 of the world’s population will experience stress by 2025; for one billion, this stress will be severe. Sound management of water underpins every aspect of development. It is a cross-cutting concern. It is everywhere, yet nowhere in our discussions.”

They were supported by a range of countries, from Chile and El Salvador to Lesotho and Syria, which highlighted that droughts have halved that country’s agricultural production. As a result, at preparatory sessions ahead of the Durban meeting, water is getting onto the agenda.

Specifically, since significant climate change is considered to be inevitable, the call is for water resource management to be recognised as an important strategic response. If “climate resilience” is the goal for climate adaptation, the slogan is that “better water resource management today will ensure that countries are better prepared for climate change tomorrow”.

An important part of this campaign is to ensure that some of the huge amounts of money that are being mobilised to tackle climate change should be spent on strengthening water resource management, i.e. improving monitoring networks and planning tools, ensuring that management organisations are staffed with appropriately trained personnel, building the infrastructure – both the hardware of storage and flood protection, as well as the software of institutions and management capability – to deal with the challenges that the future will bring.

The immediate goal sounds very bureaucratic. It is that the governments who make up the UNFCCC should support the creation of a “Thematic Funding Window on Water Resources Management under the Green Climate Fund”. The idea is that such a “funding window should provide the resources to scale up investments in the “3 I’s” of water management: Infrastructure, Information and Institutions, and to promote the integration of water security and climate resilience in national development planning and decision-making processes.”

Since the target is for the Green Climate Fund to start with US$30 billion a year and grow to US$100 billion a year, this could have a huge impact on water resource management. Just a few percent of that fund could transform hydrological monitoring in Africa and Asia; it could give hydrologists and water resource specialists in poorer countries greater job security; and most important, it could enable institutions to engage in more detail with the people who actually use water to build better understanding of the management challenges and options that they face.

So, this is a campaign that all water professionals should join, regardless of their views on the likelihood, timing and impact of climate change.
Assessment of the ultimate potential
and future marginal cost
of water resources in South Africa

SOUTH AFRICA is rapidly approaching the full utilisation of its fresh water resources, and most of the remaining potential has already been committed to be developed. The good news, however, is that it is highly unlikely that our country will “run out” of water resources, although we could end up paying a lot more for fresh water due to the planning, development and intervention initiatives that will be required to sustain the requirement for water, according to a report, An Assessment of the Ultimate and Future Marginal Cost of Water Resources in South Africa, that was commissioned by the Department of Water Affairs (DWA) last year.

Continuous population and economic growth, together with increasing industrialisation (for example, power generation and mining development) means that the requirements for fresh water resources are increasing. In some geographic areas of the country the demand for water will even increase beyond the potential of the fresh water resources that could serve them. Long-term planning and carefully mapped strategies for sourcing and supplying water are therefore critical for ensuring that water availability is sufficient to satisfy the country’s needs in the future.

It is for this reason that the DWA has, over the past few years, embarked on several Reconciliation Studies in water systems across the country to reconcile future water requirements with available resources for the: Vaal River System Crocodile West River System KwaZulu-Natal Coastal Metropolitan Areas Western Cape Water Supply System Algoa Water Supply Area Amatola Bulk Water Supply System, and the Greater Bloemfontein Water Supply Area. Following on these, the DWA appointed BKS (Pty) Ltd to bring the cost of development options identified in the various Reconciliation Strategies together in such a way that they could be compared on a common basis, and provide a more integrated and holistic view of how the country is to be supplied with water over the next 25 to 30 years. The study aimed at providing a clearer perspective on: the cost implications of various development options how South Africa’s water resources are likely to become further integrated due to the greater need for water transfer development planning with a better perspective of the future cost of water across the country for the likes of the DWA, Eskom, mines and other major users the amount of water available in each of the water supply systems, and if/or approximately when the fresh water resources will be fully utilised. While the study addressed the whole of South Africa, it has focused on the key growth areas listed in Table 1 and shown in Figure 1 in order to provide a realistic future perspective.
APPROACH

Future requirements for water

Projections of future water requirements from the Reconciliation Studies were generally available up until about 2035, and these were extrapolated until 2050 to extend the horizon for which water resources are assessed. Various water requirement projection scenarios were available, and from these a single reference planning scenario for each of the areas was selected in consultation with the relevant officials or advisors. Importantly, estimates of

Table 1: Key growth areas included in the study

<table>
<thead>
<tr>
<th>Key Growth Area</th>
<th>Area/Sector Supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaal River System</td>
<td>Urban, industrial and mining developments in Gauteng and parts of the Mpumalanga and North-West provinces, as well as water supply to the Eskom power stations in Mpumalanga and the Free State provinces</td>
</tr>
<tr>
<td>Orange River System</td>
<td>Irrigation developments along the lower Orange River (also in Namibia), the Fish-Sundays irrigation areas and Port Elizabeth in the Algoa Area. This system is integrally linked to the Vaal River System by the Lesotho Highlands Water Project and through the natural confluence of the two rivers</td>
</tr>
<tr>
<td>Lephalale Area</td>
<td>Several large coal-fired power stations and petrochemical industries are planned for this area, together with accompanying mining developments</td>
</tr>
<tr>
<td>Olifants River System</td>
<td>Witbank / Middelburg area, irrigation and mining developments of the platinum group metals, as well as the Kruger National Park</td>
</tr>
<tr>
<td>Mhlauze System</td>
<td>Richards Bay area, irrigation development in the catchment</td>
</tr>
<tr>
<td>KwaZulu-Natal Coastal Metropolitan Areas</td>
<td>Durban / Pietermaritzburg area and environs</td>
</tr>
<tr>
<td>Amatole System</td>
<td>East London area environs</td>
</tr>
<tr>
<td>Algoa Area</td>
<td>Port Elizabeth (which receives water from local resources and the Orange River via the Orange-Fish-Sundays transfer)</td>
</tr>
<tr>
<td>Outeniqua Coastal Area</td>
<td>Knysna, George and Mossel Bay urban areas</td>
</tr>
<tr>
<td>Western Cape System</td>
<td>An integration of local or regional water resources to supply Cape Town, urban users, and irrigation along th Berg and Sondereend rivers</td>
</tr>
<tr>
<td>Remainder of South Africa</td>
<td>Predominantly rural parts of South Africa</td>
</tr>
</tbody>
</table>
possible savings achievable through the implementation of water conservation and water demand management (WC/WDM) were also obtained. WC/WDM is considered as an investment that can reduce water requirement and thereby extend the sufficiency of the existing water resources, and should be viewed in the same light as investments in water resource development projects. The expected growth in water requirements is predominantly in the urban, industrial, mining and power-generation sectors. With the exception of the provisions listed in the National Water Resources Strategy for irrigation developments, no other growth in water for irrigation was provided for.

**Water resources and options for augmentation**

Water resource development options that can augment current water availability and reconcile future water requirements, were considered from the Reconciliation Studies, as well as other recent assessments of surface water, groundwater, return flows, inter-basin water transfers, development options, and the desalination of sea water. Desalinating sea water and pumping it to where it may be needed, was regarded as the ultimate source of water in all cases, as a last resort once all other options have been fully exploited. While the cost of such water is likely to be prohibitive for inland locations, it is a valuable and often sobering reference.

**Basis for comparison and standardisation**

To determine future water costs for each area, and on a national basis, the construction cost estimates for the various water resource development options from reports spanning more than two decades were adjusted to a common base. Movements and trends in the Consumer Price Index (CPI) and the Construction Price Adjustment Factors (CPAF) from January 1992 until June 2009 were considered for

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### Typical Programme for Water Resource Developments

<table>
<thead>
<tr>
<th>Phase</th>
<th>Timeframe</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Reconnaissance Phase</strong></td>
<td>1 – 5 years</td>
<td>Needs identification, identification and selection of possible interventions</td>
</tr>
<tr>
<td><strong>2. Pre-feasibility Phase</strong></td>
<td>1 – 3 years</td>
<td>Preliminary investigation of alternatives (options)</td>
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<td></td>
<td></td>
<td>Identify cost options for detail study</td>
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<tr>
<td><strong>3. Feasibility Phase</strong></td>
<td>2 – 4 years</td>
<td>Detailed investigation and assessment of best options, rating and configuration (technical, environmental and cost)</td>
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<td></td>
<td></td>
<td>Recommendation of project</td>
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<tr>
<td><strong>4. Decision Support Phase</strong></td>
<td>2 – 5 years</td>
<td>Environmental appraisal, Reserve determination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Public involvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Initial funding and institutional arrangements</td>
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<tr>
<td></td>
<td></td>
<td>Some optimisation</td>
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<tr>
<td></td>
<td></td>
<td>Decision to implement</td>
</tr>
<tr>
<td><strong>5. Design/Documentation Phase</strong></td>
<td>2 – 6 years</td>
<td>Reformulate institutional arrangements, Secure funding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Procurement procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engineering design and construction documentation</td>
</tr>
<tr>
<td><strong>6. Construction/Implementation Phase</strong></td>
<td>4 – 8 years</td>
<td>Procurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-sealment and compensation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impounding and commissioning</td>
</tr>
</tbody>
</table>

**Notes:**

1) Numbers in brackets indicative of average periods.
2) Some of the activities typically extend over more than one phase, such as public involvement.
3) Determination of the Reserve should be independent from any specific project development. However, where the Reserve has not previously been determined, it may be included under the development programme. It is therefore not restricted to a specific phase.

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### Western Cape System augmentation options

- **Desalination of seawater**
- **Reuse of water**
- **Upper Molenas Diversion**
- **Michell’s Pass Diversion**
- **Groundwater (TMG Aquifer)**
- **Voëske Klip Augmentation Ph1**
- **Voëlklip Augmentation Ph2 & 3**

*Legend: 0.45 - Unit energy requirement kWh/m³ of water*
According to African legend

When respect ceases, it will be the end of the world. There is a message for us all in that legend. For when we cease to honour our environment, cease to respect the gifts of the earth, we place ourselves and our world in grave danger. At AfriSam, we don’t just talk “environmentally friendly” – we really walk our talk. Our Eco Readymix concrete range provides all the strength and quality of standard concrete yet leaves a much lower Carbon Footprint. So think Eco, when you think construction and commit to building for the future.

I AM AFRISAM
escalating the costs. Interestingly, these two indices differed significantly over the last 5 years, primarily due to influences of fuel and steel costs. The CPAF was adopted as it better accounted for the factors that affect a large water resource development project. Apart from escalating costs to a common date, an effort was made to bring the level of detail on the various schemes to a more common level.

To compare water resource development options of different sizes from a cost perspective, the unit cost of water for each scheme was determined, expressed in terms of unit reference value (URV). The URVs were representative of the marginal cost of water in preference to the price of water, as the latter is often skewed by the blend of old and new infrastructure investments. It must be stressed that URVs are therefore not reflective of water tariffs. The following general assumptions, of importance when interpreting results, were made:

■ URVs are representative of raw water. Where desalination of sea water and acid mine drainage produced potable water, the treatment cost was subtracted to reflect the raw water equivalent.

■ Energy costs were based on representative marginal cost for electricity, assuming that all new generation until 2019 will be from coal-fired power stations (at 60c/kWh), and half of the generation from 2020 onwards will be from nuclear power (at R1,20/kWh), resulting in an average marginal rate of 90 cents per kWh. Provisions were made for transmission costs, depending on the distance of the source of supply from the area being supplied.

■ Capital, energy, operation and maintenance costs were escalated to mid-2009 money values, excluding VAT as it is not relevant from a national perspective.

INDICATIVE PHASING AND THE FUTURE COST OF WATER

To provide an indication of approximately when the different water resource development options of increasing cost will be needed, an indicative phasing in of development options was conducted for each of the areas included in the study. The projected phasing in of options within each of the areas was based on meeting the projected future water requirements, and also took

[Western Cape System augmentation options (includes the negative effects of climate change in the Western Cape)]

[Vaal River System augmentation options]
cognisance of the time still required to implement the various water resource development options. Development of new water resources is a complex and time-consuming process which typically takes more than a decade from inception to completion (shown in Figure 2). Lead times on larger and more complex projects that include environmental and political sensitivities may be more than two decades, which stresses the importance of identifying and planning for water resources long before the resource is actually needed.

The water resource development options for each area were ranked and phased in according with the unit cost of water (the lowest being preferable). If two options had the same URV, the one with the lower unit energy requirement was given priority. If the highest-ranking scheme would be unable to deliver water in time (due to its position in the development cycle), the next best option that could be implemented to meet the requirement was used. Short-term interim deficits were unavoidable in a few cases where none of the options appeared to be ready for development in time to meet the growing water requirements.

Although in reality, actual water requirements in the future may differ somewhat from the projections adopted, and consequently the required implementation dates of future water resource developments, the indicative phasing does provide a good indication of the likely magnitude of the future marginal cost of water in each of the main growth areas of the country, and how it is likely to increase over time.

INFRASTRUCTURE DEVELOPMENT OPTIONS AND RECONCILIATION SCENARIOS
An example: the Western Cape System and a comparison with the Vaal River System

Results from one of the focus areas of the study, the Western Cape System, showed that, due to the projected rapid growth of water requirements, this region is one of the areas in greatest need of the augmentation of water resources. Development options identified to augment water supply in the Western Cape in future are comparatively illustrated in Figure 3.

Based on the URVs, the energy required and possible implementation time frames, the indicative phasing in of these development options is shown in Figure 4. Note the possible decline projected in existing yield as the impacts of climate change manifests. The final size and scheduling of the future development options will be optimised during more detailed studies closer to the required development dates as part of the ongoing maintenance plan of the Reconciliations Studies.

Results show that the fresh water resources within practical and economic proximity of the Western Cape System have almost been fully developed and utilised, leaving only options for some incremental developments. Combined, these options would yield only enough water to meet increasing requirements until about 2026, after which the system would have to be augmented by the re-use of water, and then the desalination of sea water.

The cost of future water in the Western Cape can be broadly grouped into surface water and groundwater schemes at a marginal cost of R2/m³ to R4/m³, followed by the re-use of water at around R8/m³ and ultimately the desalination of sea water at a cost of approximately R12/m³.

When compared to the water resource development options identified in the Vaal River System (Figure 5), it is evident that
the cost of water from developments in the Vaal River System is approximately double the cost of water from developments in the coastal areas such as the Western Cape System.

Phase 2 of the Lesotho Highlands Water Project (LHWP), a favourable surface water development for the Vaal River system, will provide water at approximately R6/m³. The next generation of surface water development and the use of treated water from acid mine drainage are in the order of R10/m³. The last fresh water resource to be developed, the Mzimvubu River, can provide water to the Vaal at a cost of around R18/m³, which is 50% more than desalination at the coast. As an ultimate source, the desalination of sea water, and pumping it to the Vaal, will cost approximately R25/m³. The cost of water transferred from the Zambezi River is of similar magnitude as desalination and pumping of sea water. However, considering the complexity and likely difficulty in negotiating water agreements with the eight co-basin states of the Zambezi River, this will probably not ever be an option.

Similar to the above, results from the other focus areas included in the study can be found in the report on DWA’s website (see Note on page 19).

**FINANCIAL AND ENERGY REQUIREMENTS**

In order to measure the future national financial requirements of water resource developments in South Africa, capital and operation and maintenance cost streams were developed. Figure 6 summarises this information for all of the regions until 2050 and shows that capital costs will be relatively high over the next 10–15 years as infrastructure still needs to be rapidly developed. Once implementation of infrastructure slows down, capital costs trend lower, while operation and maintenance costs rise steadily, predominantly due to increased pumping and desalination costs.

The study also estimated the future energy requirements that would be associated with the various new development options indicated, but only for new developments. Indications are that about 1 000 MW of additional electricity will be required for new water resource projects by 2050, including future pumping of water to the Vaal River System supply area and the desalination of sea water.
STUDY OUTCOMES AND RECOMMENDATIONS

Sufficient water can be made available to meet future needs in all major urban and industrial centres in South Africa, although at steeply increasing costs in most cases, often to the point of exceeding the value of some existing water uses. The full utilisation of fresh water resources will also not be reached at a common date throughout the country, but at different dates over an extended period of time.

The greater Cape Town area, specifically, is likely to become totally dependent on the re-use of water, and eventually on the desalination of sea water, by about 2030.

The most critical situation is with respect to the Olifants River system where a deficit already exists. This will be felt with the implementation of releases for the ecological Reserve. Lastly, large-scale augmentation of resources to the Vaal River system will be at a substantial cost and the re-allocation of water between sectors should be seriously considered.

Ultimately, this study identified that further work on the value of water in different sectors and usage types needs to be conducted in order to judiciously guide the allocation and possible re-allocation of water resources, obviously with due consideration to related social, political and strategic aspects.

Note

For more information on this study and related studies, please read:
- An Assessment of the Ultimate Potential and Future Marginal Cost of Water Resources in South Africa, 2010
- Crop Production Potential in South Africa’s Neighbouring Countries, 2010

Impressed by SBS’s performance, the uMgungundlovu district municipality approached SBS for pricing on several tanks for its new water supply scheme at Embuthweni, KwaZulu-Natal. SBS finally provided: a 150 kT tank for raw water storage prior to process/purification, two 50 kT reservoirs – one as a break pressure tank at the booster pump station, and the other as a clear water tank for pumping towards the bulk storage tanks and 28 kT reservoir for reticulated water storage.

Silvest's Simon Joubert, who recommended SBS for the project, has been specifying SBS tanks for the last decade. “Cost-wise they are affordable, coming in at 50% of the cost of a regular reinforced concrete reservoir, and their erection speed is very good,” says Joubert. “You can have the entire structure up and commissioned in a month (compared with several months for reinforced concrete reservoirs). In inaccessible places SBS reservoirs are appropriate to use in that they can be transported by hand, reducing the environmental impact of access road construction. They require a simple main beam and sand infill that can be completed by relatively unskilled teams. They are also easy to repair, can be moved, and the life of the bladder generally exceeds the design life of the water scheme.” Following SBS’s successful performance at Embuthweni, uMgungundlovu district municipality’s Siboniso Miyara became a convert. He was impressed by the speed, appearance and cost-effectiveness of the SBS reservoirs and states he would “definitely use them again.”
SBS helps municipalities store water in South Africa

Progressive technology provided by SBS Water Systems is assisting an increasing number of municipalities and engineers to speed up the delivery of safe, affordable water storage.

Years of research and development, together with close liaison with local government departments and district municipalities, led to SBS pioneering the use of prefabricated Zincalume steel reservoirs with internal liners for municipal and rural water storage in South Africa in the late 90's.

Today, the company’s range of storage tanks, which includes the industry benchmark Galaxy™ Reservoir, are the preferred solution for a host of storage applications:

- Bulk Water storage for municipalities
- Water storage for community water supply schemes in rural villages
- Commercial water storage within production plants and factories
- Fire Water storage for fire protection sprinkler and hydrant systems (ASIB)
- Waste water and treatment plants including sewage
- Mining
- Export projects made easy by the modular design of the SBS tanks
- Agriculture
- Domestic use with the introduction of smaller under eave tanks

An affiliate of IMESA and WISA since 2008, SBS is mindful of the challenges that face municipalities and engineers trying to provide safe, affordable water storage solutions. SBS assists by offering a high-quality technically advanced, cost effective and rapidly installed alternative to conventional reinforced concrete reservoirs.

SBS reservoirs are fabricated from high tensile, corrosion-resistant, cold-rolled Zinc / Aluminium / Silicone coated steel sheets, and are lined with a range of proprietary, multilayer liners. A variety of tank designs are available for different applications, ranging in capacity from 10 kℓ to 2.58 million litres.

Proof of SBS’s impact in the area of municipal and rural water storage is the increasing number of South African municipalities that have transitioned from traditional concrete to SBS reservoirs.

Ilembe, uMzinyathi, OR Tambo, uThungulu and uMgungundlovu district municipalities have all made the shift.

SBS prides itself on the speed and accuracy of its installations and only utilises fully trained SBS employed installers with years of field experience both within SA and internationally.

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Benchmarking and tracking of water losses in all municipalities of South Africa

**OVERVIEW**

South Africa is a water-scarce country with an annual runoff that is less than 13% of the world average. In addition, the country has a very uneven rainfall distribution varying from 10 mm/annum in the west to over 2 000 mm/annum in the Drakensberg Mountains in the east. Despite limited water resources and continually increasing demands, very few municipalities can provide accurate water balance data and most have no accurate record-keeping of their input volume or billed consumption. *An Assessment of Non-Revenue Water in South Africa*, a study completed for the SA Water Research Commission (Seago & McKenzie 2005), estimated the total water losses (real and apparent) for 62 systems analysed to be in the order of 670 million m³/annum or 31% of the total urban water supplied. The non-revenue water (NRW) is effectively the sum of the total water losses and the estimated unbilled consumption. The unbilled consumption was conservatively estimated to be approximately 104 million m³/annum, which in turn provided an estimate of 774 million m³/annum for the non-revenue water, i.e. approximately 36% of the water supplied. Estimating the unbilled consumption was difficult in many areas due to a lack of reliable information. However, it was estimated in the cases where proper data was available and subsequently extrapolated to cover the whole country.

The results from this study have been quoted extensively and are considered one of the most reliable sources of quantifying water losses in South Africa. Water losses in South Africa are generally considered very high, but the exact extent of the problem has not been properly defined. Subsequently, various Directorates in the Department of Water Affairs (DWA) and the South African Water Research Commission (WRC) have joined forces to establish a better understanding of water losses in South Africa. This article describes the various sources of information, procedures and processes that have been put in place to derive the latest estimate of water losses and non-revenue water from municipal water supply systems in South Africa.

**INTRODUCTION**

The water losses from municipal water supply systems country-wide have been under investigation for many years. Various projects in the past, locally and abroad, have been conducted to develop...
a standard methodology and appropriate key performance indicators (KPIs) to establish and quantify the magnitude of losses.

To ensure that all water supply institutions across the world define their water losses in a similar way, the International Water Association (IWA) has developed a standard water balance. The components of the standard IWA water balance are shown in Figure 1 and discussed in detail in the second part of this article. It should be noted that the “Revenue Water” component of the standard IWA water balance has been modified slightly (WRC Report No TT300/07, 2007) for use in South Africa. This change was considered necessary to deal with the free-basic water allowance which is a key issue in South Africa.

NRW is defined as the volume of water used by the municipality for which no income is received. It should be noted that the standard IWA water balance is a volumetric water balance and not a financial balance. For purposes of calculating the NRW in this report it is assumed that all billed water is paid for, although it is accepted that payment is a problem in many parts of the country. It should also be noted that revenue water includes free-basic-water, which is considered to be billed at a zero rate.

Expressing the NRW as a percentage of the system input volume is not encouraged, as it can be misleading due to the fact that percentage figures are strongly influenced by the consumption. Percentage NRW is, however, still used extensively in the industry and, while it can be misleading, it is acknowledged that it will continue to be used as the indicator of choice by most officials.

Previous studies undertaken by the WRC and DWA have provided significant detail on the methodology and terminology, which is not repeated in this review. The previous work was also based on a smaller sample of municipalities, due to budget limitations and lack of reliable data. The review discussed in this article includes information from all municipalities and the assessment therefore provides a more reliable estimate of the NRW for the country as a whole.

It should be noted that the work undertaken in this assessment is based on ongoing studies undertaken by the WRC and DWA.

WATER BALANCE TERMINOLOGY
In many water balance assessments, the term ‘unaccounted for water’ (UAW or UFW) is used to indicate the level of leakage in a water distribution system and has become the standard term adopted by most utilities around the world. This term, however, is open to some level of subjective judgement, with the result that it can be manipulated based on the various assumptions used in its calculation. Numerous papers and presentations on the subject have been presented at conferences around the world, and all clearly recommend that the term UAW is replaced with the term ‘non-revenue water’ (NRW), which cannot be manipulated to the same extent.

As mentioned previously, the objective of the study was to perform a high-level non-revenue water assessment of all municipalities in the country based on the IWA’s standard water balance. The standard water balance proposed by the International Water Association (IWA) was modified slightly to accommodate the free-basic-water allowance, which is an important component of all water balances in South Africa. The water balance used in the assessments is shown in Figure 1 and described in the following paragraphs.

Apparent losses
Apparent losses are made up from the unauthorised consumption (theft or illegal use) plus all technical and administrative inaccuracies associated with customer metering. While it should be noted that the apparent losses should not be a major component of the water balance in most developed countries, it can represent the major element of the total losses in many developing countries. A systematic estimate should be made from local knowledge of the system and an analysis of technical and administrative aspects of the customer metering system.

Authorised consumption
Authorised consumption is the volume of metered (authorised metered) and/or unmetered (authorised unmetered) water taken by registered customers, the water supplier and others who are implicitly or explicitly authorised to do so by the water supplier, for residential, commercial and industrial purposes. It should be noted that the authorised consumption also includes water exported to neighbouring water authorities and, in some cases, may include items such as fire-fighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, building water, etc. These may be billed or unbilled, metered or unmetered, according to local practice.

Billed authorised consumption
Billed authorised consumption is the volume of authorised consumption which is billed by the Water Services Authority (WSA) and paid for by the customer. It is effectively the revenue water, which, in turn, comprises:
- billed metered consumption
- billed unmetered consumption.

Non-revenue water
Non-revenue water is becoming the standard term replacing unaccounted-for water (UAW) in many water balance calculations and, as mentioned above, is the term recommended by the International Water Association. It is a term that can be clearly defined, unlike the unaccounted-for water term, which often represents different components to the various water suppliers. Non-revenue water incorporates the following items:
- unbilled authorised consumption
- apparent losses
- real losses.

Real losses
Real losses are the physical water losses from the pressurised system, up to the point of measurement of customer use. In most cases, the real losses represent the unknown component in the overall water balance, and the purpose of most water balance models is therefore to estimate the magnitude of the real losses so that the WSA can gauge whether or not it has a serious leakage problem. The real losses are generally calculated as the difference between the total losses and the estimated apparent losses.

System input
The system input represents the volume input to the water supply system from the WSA’s own sources, allowing for all known errors (i.e. errors on bulk water meters), as well as any water imported from other sources – also corrected for known bulk metering errors.

Unbilled authorised consumption
The unbilled authorised consumption is the volume of authorised consumption
that is not billed or paid for. The level of unbilled authorised consumption will vary from WSA to WSA. In some areas virtually all water is metered and billed in some manner, with the result that the unbilled authorised consumption is zero.

Water losses

Water losses are the sum of the real and apparent losses and are calculated from the difference between the total system input and the authorised consumption. In most countries the water losses are also considered to be the unaccounted-for water (UFW), although the exact definition of the UFW can vary from country to country.

Key performance indicators (KPIs)

The IWA has developed various water loss key performance indicators to evaluate and compare different distribution systems. Calculating KPIs depends on the availability of information, which is not always obtainable.

Based on the availability of information, the following KPIs have been used in the study:

- **Percentage NRW**: Although the use of percentages to define water losses is not recommended by the IWA, the term is widely accepted and used in the South African water industry. For this reason it has been retained, although it should be used with caution in the knowledge that it can sometimes be misleading. The percentage NRW is calculated as shown in Equation 1.

\[
\text{% NRW} = \frac{\text{billed consumption}}{\text{system input volume}} \times 100 \quad (1)
\]

- **Litres/capita/day**: This provides an indication of the gross volume of water used per capita (person) per day. Although the calculation is based on the total system input volume (m³/annum) and not just the domestic component of water use and, if necessary, it should be excluded from the calculation in order to derive a more realistic per capita consumption. The \(\ell/c/d\) is calculated as shown in Equation 2.

\[
\ell/c/d = \frac{\text{system input volume} \times 1000}{365 \times \text{population}} \quad (2)
\]

**METHODOLOGY**

**Data sources**

The main data sources used in the study are summarised as follows:

- 2009 Regulatory Performance Measurement System
- Data provided by municipalities
- DWA NIS demographic data
- Water Services Development Plans

Unfortunately the non-revenue water assessment was not included in the 2008 Stats SA Non-Financial Census of Municipalities.

These data sets were supported by the following:

- All Town Reconciliation Strategy Study
- 2005, 2006 and 2007 Stats SA Financial Census of Municipalities

**Grouping**

The data was categorised according to the Municipal Infrastructure Investment Framework (MIIF) as summarised in Table 1.

**RESULTS**

**National water balance**

Details of the national water balance are shown in Figure 2.

It should be noted that the national water balance is highly influenced by data from the metros and municipalities with large cities. The water balance shown also represents only 45% of municipalities, with very limited information regarding the remaining 55%, although it does cover over 56% of the total water demand by volume.

In the water balance calculation, once an account has been generated, the water being billed is considered to be part of the authorised billed consumption. The calculation does not look beyond the billing stage into the payment process, which is considered to be a completely separate, albeit important, issue. Levels of payment are very low in some parts of the country and this

---

**Table 1 Municipal categories**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Metros: 6 x metropolitan municipalities</td>
</tr>
<tr>
<td>B1</td>
<td>Major cities: 21 x secondary cities, local municipalities with the largest budgets</td>
</tr>
<tr>
<td>B2</td>
<td>Minor cities: 29 x municipalities with a large town as core</td>
</tr>
<tr>
<td>B3</td>
<td>Rural dense: 111 x municipalities with relatively small population and significant proportion of urban population, but with no large town as core</td>
</tr>
<tr>
<td>B4</td>
<td>Rural scattered: 70 x municipalities which are mainly rural with, at most, one or two small towns in their area</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>System Input Volume</th>
<th>100.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorised Consumption</td>
<td>70.3%</td>
</tr>
<tr>
<td>Billed Authorised</td>
<td>65.3%</td>
</tr>
<tr>
<td>Revenue Water</td>
<td>65.3%</td>
</tr>
<tr>
<td>Non-Revenue Water</td>
<td>34.7%</td>
</tr>
<tr>
<td>Real or Physical Loss</td>
<td>23.8%</td>
</tr>
<tr>
<td>Apparent or Commercial Loss</td>
<td>5.9%</td>
</tr>
<tr>
<td>Unbilled Authorised</td>
<td>1.0%</td>
</tr>
</tbody>
</table>
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inadvertently has a major influence on the NRW since there is little incentive to save water when the user has no intention of paying for it. The cost recovery aspect is not part of the NRW calculation, either in South Africa or elsewhere in the world, and must be addressed through a social and community education programme.

Very limited information exists on the unbilled authorised consumption, which was estimated at 5% of the input volume. The apparent or commercial losses were also estimated at 20% of the total water loss, but vary considerably between municipalities, due to the different ages of the infrastructure and the various meter replacement policies adopted by each municipality. It is estimated that apparent losses could be as high as 50% of the water loss in some municipalities and as low as 5% in others.

Key performance indicators
The percentage non-revenue water per municipal category, based on usable data sets, is shown in Figure 3.

The NRW varies between 20% and 40%, with most of the categories indicating an upward trend over the past five years. The NRW for municipalities in categories A and B1 are all near 35%, with municipalities in category B3 at around 25%. The lower NRW in category B3 is thought to be due to the fact that these towns are easier to manage, with the result that the NRW is under control. The data for municipalities in categories B3 and B4 is very limited and erratic, and it is therefore difficult to make a realistic estimate of the NRW. Fortunately the volumes of water used in these areas are relatively small, with the result that the errors do not have a significant influence on the overall NRW estimate.

The 2008 results are rather erratic and inconclusive since they are based on a very small sample size.

The national NRW figures compare well with international trends as shown in Figure 4. The average NRW over the past five years for various countries across the world is 36.6%, ranging from over 70% in developing countries such as Albania and Armenia to below 10% in highly developed countries such as Australia and New Zealand.

The litres/capita/day per category, based on usable data sets, are shown in Figure 5.

The average ℓ/c/d for the metros are the highest, but this is to be expected,
since the total water demand includes the industrial water use and this tends to be relatively high in most metros which support the highest number of wet industries in the country. Although the data sets for categories B3 and B4 are much smaller, the average per capita consumption seems significantly lower than for the bigger municipalities. The national average water consumption varies between less than 226 ℓ/c/d in 2005 to 286 ℓ/c/d in 2009.

The average per capita consumption for South Africa is high compared to most

![Average litres/capita/day (2005 – 2009)](source: IBNET)

other countries, as shown in Figure 6. The international gross average consumption is 173 ℓ/c/d.

**STRATEGIC OVERVIEW**

**Data Quality**

It was found that the quality of the data presented by municipalities is very poor, especially for the smaller and rural municipalities. In some cases, municipalities have provided the same information for two or three consecutive years, indicating that this information is not updated on an annual basis. A further concern is that a significant number of the municipalities could not even provide a system input volume, indicating that measurement processes are neither adequate nor effective. It is clear from the observations noted above that water demand management is not taking place, even at a rudimentary level in many areas. In the absence of proper metering and monitoring, appropriate reliable planning cannot be undertaken.

**Extrapolated NRW**

The estimated national non-revenue water is estimated to be in the order of 1 500 million m³/annum if extrapolated for the whole country. This is approximately one third of the total water supplied and almost equal to the total Rand Water supply per annum. At the estimated average bulk supply tariff of US$ 0.60/kℓ, the value of non-revenue water amounts to almost US$ 1 billion/annum.

It is very difficult to assess how much water could be saved since it is never possible to eliminate all of the non-revenue water. Using the results from previous studies, it is estimated that approximately 40% to 50%, or about 600 to 750 million m³ of the NRW, could be saved, representing almost 13 to 17% of the system input volume.

**Key interventions required**

Water losses in a distribution network are often an indication of the ‘health’ of the water distribution network, as
most WC/WDM activities are related to the operation and maintenance of the system. In a well-managed system the input volume will be known, leaks will be fixed, consumers will be metered and billed, there will be limited disruption in the supply and pressures will be within the acceptable range.

The Water Services Act (Act 108 of 1997) and the Regulations Relating to Compulsory National Standards and Measures to Conserve Water (RS09 of 2001) under the Water Services Act of 1997 require Water Services Institutions to perform certain functions to report on and control their water losses. Although the Act and regulations are very clear on what is required from Water Services Institutions, these functions are often not performed and are the very core of water losses in most water distribution networks. Enforcing the requirements of the Water Services Regulations would make a tremendous difference in the reduction of water losses in the country and should focus on the following:

- resolving intermittent supply and focusing on providing a proper service
- fixing of internal plumbing leakage by municipalities, regardless of whether services are paid for or not
- fixing of visible leaks on the distribution network
- bulk metering and calculations of non-revenue water
- accurate metering, reading and billing
- consumer awareness and elimination of inefficient use.

CONCLUSIONS AND RECOMMENDATIONS

- With each new assessment, more information becomes available and the extent of extrapolation therefore decreases and the reliability of the overall assessment improves. The results discussed in this article are therefore the most comprehensive national non-revenue water database compiled to date.
- NRW appears to have increased over the past five years from approximately 30% to approximately 35%, although this conclusion should be treated with caution since the earlier data sets involved a greater level of extrapolation than the more recent data sets. Only continuous monitoring, analysis and feedback will improve results. Data must be scrutinised for errors and analysed based on KPIs. It is expected that participation will improve once municipalities gain confidence and receive feedback from the DWA on their results. Municipalities will wish to compare themselves with other municipalities, and this should be promoted as a key motivation for municipalities to participate and support the annual water balance assessments.
- A web-based application is considered to enable municipalities to enter their data online. Once the data has been submitted, it should be scrutinised by the database manager and checked for errors. Feedback should be provided to the municipality on acceptance or rejection of data sets. Once the data sets have been accepted, the municipality will gain access to national and provincial reports for comparative purposes.
- Based on the state and quality of the data obtained from the municipalities, it is evident that a nation-wide training programme is required on the basic principles of water demand management, with specific reference to the development of a meaningful and realistic water balance. The data obtained to date from many municipalities highlights many serious inaccuracies or errors, which may be due to a general lack of understanding of the water balance. With improved knowledge and understanding of the water balance and basic WDM principles, it is anticipated that the quality and usefulness of the data will improve.
- Additional data will be required to calculate other key performance indicators. This data should include the length of mains, average system pressure, number of connections (metered and unmetered) and domestic and non-domestic water use, etc.
- A major concern is the lack of information for 55% of the municipalities. Lack of resources and metering, ignorance, continuous crisis management and apathy are some of the reasons given for this lack of information. These problems must be addressed as a matter of urgency.
- The Blue and Green Drop assessments have been very useful in assessing the condition of water and waste water treatment works in South Africa. Indications are that participation by municipalities, as well as data quality, has improved significantly over the past few years. It is proposed that a NRW assessment is performed for each municipality. This will provide an opportunity to gain insight into problem areas and how they can be resolved.

Very few municipalities can provide a comprehensive water conservation and water demand management (WC/WDM) strategy that sets targets, intervention programmes and budget requirements. The lack of information for 55% of the municipalities suggests that almost half of the country’s municipalities are not even aware they have a problem. As part of the National Water Audit, support should be given to municipalities on the development of WC/WDM strategies, which can then be rolled up to provincial and national strategies. In this regard, the WRC has just released its WDM Strategy Scorecard Model, which is an ideal tool for assisting water suppliers in developing a simple and pragmatic WDM strategy.

Various government departments have spent considerable time and money collecting and collating NRW data. This data is of little value unless it is verified, validated and converted into reliable information which can be used for planning purposes.

REFERENCES

Personal communications with various municipalities.


The International Benchmarking Network for Water and Sanitation Utilities (IBNET). Information obtained from website http://www.ib-net.org

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Spring Grove Dam: augmentation of water supply for KwaZulu-Natal

INTRODUCTION
The management of the water resource infrastructure in South Africa is mostly guided by the principles contained in the following documents:

The fundamental objectives for managing South Africa’s water resources are to achieve equitable access to water resources and their sustainable and efficient utilisation. According to the National Water Resources Strategy (NWRS), although the country’s water resources are limited and highly variable, they will be sufficient to support social and economic development for the foreseeable future, provided they are judiciously managed and wisely allocated and utilised.

The NWRS provides a clear indication of the overall state of the country’s water resources as at 2000, with projections up to 2025. The water resources situation was further reviewed through the Department of Water Affairs’ (DWA) Internal Strategic Perspective (ISP), and the need for water reconciliation strategy studies in South Africa’s major metropolitan areas was identified. This was to ensure that water would not be a limiting factor to economic development. The purposes of the water reconciliation strategies were to:
- develop future water requirement scenarios
- investigate all possible water resources and other interventions
- investigate all possible methods for reconciling the requirements for water with the available resources
- provide recommendations for the development and implementation of the interventions and actions required, and
- propose a system for continuous updating into the future.

The implementation of Phase 2 of the Mooi–Mgeni Transfer Scheme was one of the recommended interventions that emanated from the water reconciliation strategy study for KwaZulu-Natal Coastal Metropolitan Areas.

MOOI–MGENI TRANSFER SCHEME
Spring Grove Dam and the water transfer scheme form Phase 2 of the Mooi–Mgeni Transfer Scheme (MMTS-2). It will transfer water from the Mooi River catchment to the Umgeni River catchment to augment water supplies, via the Midmar Dam, for domestic and industrial users downstream of the Midmar Dam.

Construction of the Spring Grove Dam officially commenced on
21 February 2011, almost five years since the DWA’s decision to proceed with the development of the Spring Grove Dam and transfer pipeline near Rosetta in KwaZulu-Natal.

BACKGROUND ON THE MMTS-1 AND MMTS-2

The Mgeni System comprises the Midmar, Albert Falls, Nagle and Inanda Dams in KwaZulu-Natal, and a transfer scheme from the Mooi River. It supplies domestic and industrial water to around five million people, and industries, in the Durban and Pietermaritzburg regions. Since about 1983, the Mgeni System has been augmented by an emergency scheme that supplies water via the Mearns Weir in times of drought. Figure 1 shows the water resources in the system, as well as abstraction points, water treatment works and supply areas.

The MMTS-1, implemented at the beginning of the century, comprises a higher Mearns Weir and pump station at Mearns on the Mooi River, which pumps water 13.3 km to a break-pressure tank at Nottingham Road, from which it flows via an 8.3 km long gravity main to an outfall works and is discharged into the Mpofana River. From there it flows downstream along the Lions and Umgeni Rivers into the Midmar Dam.

The DWA originally implemented the transfer scheme as an emergency solution to the droughts of 1983. The original Mearns Weir had virtually no storage and the scheme was thus essentially a run-of-river scheme that could only transfer water when there was sufficient flow in either the Mooi or Little Mooi Rivers, or both.

In 2003, the scheme was upgraded as the weir was raised by 5 m to create sufficient storage to allow continuous abstraction for about one week, using the existing 3.2 m³/s pump installation. This upgraded scheme, together with the raising of the Midmar Dam in 2003, is now known as the Mooi Mgeni Transfer Scheme Phase 1 (MMTS-1).

The current Mgeni System (the four dams and the MMTS-1) has a stochastic yield of 334 million m³/annum (measured at Inanda Dam) at a 99% assurance of supply.

MOOI–MGENI TRANSFER SCHEME (PHASE 2): A SOLUTION TO SATISFY WATER DEMANDS

Figure 2 shows the actual usage of water from the Mgeni System compared to...
the amount of water that the system can provide at a 99% level of assurance. It shows that since 2003, the Mgeni System has been unable to adequately meet domestic and industrial water requirements in the downstream Durban and Pietermaritzburg areas, and the exceptional growth in water use in recent years has worsened the situation, despite the implementation of water conservation and demand measures since 1997.

A few years ago, the assurance of supply from the existing water resources of the Mgeni System dropped to less than 95%, highlighting the urgent need for a fast-track solution to augment the system and stave off the negative impacts on the regional economy.

**A FAST-TRACK SOLUTION TO WATER DEMAND INCREASES**

By 2008 water demands in the Mgeni Water System were rising faster than previously anticipated and augmentation of the water supply was urgently needed. Various augmentation schemes from within the Mgeni River were investigated but were not considered feasible, because the existing system was already fully committed and would not be able to provide water at the required assurance of supply level beyond 2009. Over the past decade or so, the DWA had undertaken numerous investigations into options for augmenting supply and, by 2009, was well under way in the planning and preparation for the construction of the Spring Grove Dam upstream of the Midmar Dam on the Mooi River (See Figure 1). The new Spring Grove Dam will augment the yield of the system by an additional 60 million m³/annum.

The Trans-Caledon Tunnel Authority (TCTA) received a Directive from the Minister of Water Affairs on 27 November 2007 to fund and implement the MMTS-2 as an agent on behalf of the DWA. In terms of the Directive, TCTA would enter into an Implementation Agreement with the DWA to undertake the funding and implementation of the MMTS-2; the DWA would enter into a raw water supply agreement with Umgeni Water (a water board as defined in the Water Services Act), and Umgeni Water would enter into off-take agreements with each of three municipalities that would be the primary water users from the MMTS-2. Once complete, the MMTS-2 will be handed over to Umgeni Water to operate and maintain the scheme on behalf of the DWA.

The Record of Decision (ROD) for the project was issued by the Department of Environmental Affairs (DEA) on 15 June 2009. TCTA appointed BKS (Pty) Ltd to review the preliminary work that had been done, develop it to a stage where competitive tenders could be obtained, finalise the design and construction drawings, supervise contractor’s activities and commission the works.

**CHARACTERISTICS OF SPRING GROVE DAM**

Located about 2 km from the town of Rosetta, the new Category III Spring Grove Dam will be situated on the Mooi River and has been designed as an RCC (roller compacted concrete) gravity dam with an earthfill embankment. Figure 3 is an artist’s impression of what the finished dam will look like. Table 1 provides more details on the principal characteristics of the dam.

Proactive planning and management of South Africa’s water resources is critical, but the actual implementation of the recommended options is the most important. The construction of Spring Grove Dam will augment the supply of water to the Mgeni River System. By late 2012, the yield of the Mgeni System will improve from 334 Mm³ to 394 Mm³ at a 99% level of assurance of supply.

The day-to-day management of water demand by some users has helped lower demand to a certain extent, but the water supply situation will remain stressed for some years to come until additional water resources are developed in the KwaZulu-Natal region.

Opportunities for further development of the available water resources are being attended to by the DWA in close consultation with stakeholders and water user groups.

**PROJECT TEAM**

DWA Principal
TCTA Implementing Agent
Umgeni Water Project Partner
BKS Consultant
Group5-Pandev Joint Venture Contractor
Municipalities and end users Beneficiaries
INTRODUCTION
In 2008 the Department of Water Affairs (DWA) appointed Aurecon and Afri-Coast Engineers to develop a reconciliation strategy for ensuring a sustainable future water supply for Nelson Mandela Bay Municipality (NMBM) and for the other towns and the irrigators served by the Algoa Water Supply System (AWSS). The reconciliation strategy was invaluable to NMBM for selecting emergency drought interventions to mitigate the effects of the severe drought of 2009/2010, which had a recurrence interval of between 1 in 50 and 1 in 100 years.

THE SYSTEM
The AWSS comprises three systems:
■ The Western System provides water to NMBM from the Churchill and Impofu dams on the Kromme River, from the Kouga Dam on the Kouga River and from the Loerie Balancing Dam on the Loerie Spruit, a tributary of the Gamtoos River. This System also supplies water to various small towns and to the Gamtoos Irrigation Board.
■ The Eastern System receives water transferred from the Gariep Dam on the Orange River via the Orange–Fish Tunnel, the Fish River, the Fish–Sundays Canal, the Skoenmakers River, and Darlington Dam.
■ The Central System consists of the older Sand, Bulk, Van Stadens and Groendal Dams and the Uitenhage Springs, all of which supply NMBM. Groendal Dam also supplies water to irrigators. The combined yield of these sources at an assurance of 1 in 50 years is 147.5 million m³/a, of which 99 million m³/a (271 Mℓ/day) is for urban use by NMBM and other small towns, and 48.5 million m³/a for irrigation. By 2010 the requirements of NMBM had grown to about 300 Mℓ/day and had exceeded the combined 1 in 50 year yield of the AWSS.

THE ALGOA RECONCILIATION STRATEGY AND THE DROUGHT
The Department of Water Affairs Reconciliation Strategy developed low- and high-growth future water requirement scenarios for NMBM for a 25-year horizon. These requirement scenarios included the probable future industrial (non-potable) water requirements of the
Coega IDZ. The Strategy investigated a number of possible future interventions that could be implemented to meet these water requirement scenarios. These interventions were assessed in terms of yield, infrastructure constraints, environmental impacts, cost for various discount rates and time taken for implementation. The interventions included water conservation and water demand management (WC/WDM), local surface water supply schemes, groundwater schemes, additional supplies from the Orange River, waste water re-use and desalination.

The development of reconciliation scenarios comprised the formulation and assessment of various sequences of intervention development to meet the alternative low- and high-growth water requirement scenarios. Eight scenarios were assessed, three of which included the possible effects of climate change and/or the potential impact of implementing ecological Reserve releases from the existing dams.

The Reconciliation Strategy assisted NMBM to identify interventions to be fast-tracked to mitigate the impact of the drought and the growth in requirements. The Strategy also showed that the construction of the schemes to treat and re-use water from the Coega and Fishwater Flats Waste Water Treatment Works for industrial use in the Coega IDZ could be deferred until about 2021, as industrial water for the Coega IDZ could initially be supplied by the Nooitgedacht Low-Level Scheme as indicated in Figure 2. Thereafter these re-use schemes should be the next major augmentation schemes for the AWSS.

The Algoa Reconciliation Strategy Study was completed in April 2010, and made the following recommendations:

- A Strategy Steering Committee with representatives from NMBM and other significant water users should be established to monitor and update the future water requirement scenarios and to monitor the implementation of the actions identified by the Strategy.
- NMBM should continue to maintain and expand the suite of water conservation and water demand management measures that it implemented during the drought emergency.
- A number of studies should be undertaken to ensure that actions can be taken and that schemes can be evaluated and, if necessary, implemented before the requirements exceed the available supplies. The interventions to be studied include alternatives if the Orange River allocation is reduced in the future, the Kouga Dam augmentation scheme, various groundwater development schemes, the use of treated waste water and the desalination of sea water.

**DROUGHT MITIGATION MEASURES**

NMBM implemented aggressive water conservation and water demand management (WC/WDM) measures as the first and most crucial step to ward off a water supply crisis arising from the drought and the growth in requirements. These measures included leak detection and repair, household plumbing repairs, an improved tariff structure, an effective awareness creation campaign, more informed billings, as well as a proactive call centre. NMBM implemented these measures rapidly and cost-effectively and, together with water restrictions, reduced the water requirements of 300 Mℓ/day (which exceeds the available 1 in 50 year yield) to less than 240 Mℓ/day.

The Reconciliation Strategy had shown that improving the operation of Loerie Dam could increase the yield of the Kouga Dam/Loerie Dam sub-system by about 14 Mℓ/day and this measure was immediately implemented by DWA, NMBM and the Gamtoos Irrigation Board. The Strategy had also identified the Nooitgedacht Low-Level Scheme, which the NMBM had been investigating as a next possible augmentation option, for accelerated implementation. This enabled NMBM to expedite this scheme which will supply an additional 90 Mℓ/day from the Orange River to NMBM. As the Orange River catchment has not been impacted by the local severe drought affecting the local sources of supply, this scheme will greatly relieve the pressure on the local supply schemes from surface water resources.
Although the Nooitgedacht Low-Level Scheme has been accelerated and is scheduled for completion by July 2012, there is still a risk that this scheme may not be implemented in time to mitigate the effects of the drought. It is therefore of paramount importance that effective water conservation and water demand management is continued and further amplified.

The NMBM also decided to take the steps that would be necessary to enable the proposed 30 Mℓ/day Swartkops Desalination Scheme to be rapidly implemented. The site of the old Swartkops Power Station was selected on account of the relatively low environmental impact that the desalination plant would have at this location, the opportunity to dispose of the brine via the existing outfall of the Fishwater Flats Waste Water Treatment Works and the proximity to existing water supply and electricity infrastructure. The engineering design and tender documentation for the desalination plant was completed within four months and the Environmental Scoping Report, supported by appropriate specialist studies, was approved within six months. However, unless the required funding can be realised, this scheme will not be constructed at this stage. The NMBM has also decided that, as the Swartkops site can only accommodate a 30 Mℓ/day desalination plant, another site should be found where further phases could also be accommodated, up to at least 70 Mℓ/day. The desalination plant is still to be constructed as the next major augmentation intervention, after completion of the Nooitgedacht Low-Level Scheme, and when funds can be sourced.

**SUMMARY**

From the foregoing it is clear that the current situation in the Algoa Water Supply System is critical. The Algoa Reconciliation Strategy has put in place various scenarios to address the challenges, and it has borne fruit even before completion, in that the NMBM was put in a position where decisions on emergency measures could be taken very quickly, because the interventions for future implementation had already been identified.
Renewable energy: hydropower

BACKGROUND OF HYDROPOWER DEVELOPMENT

Hydropower is recognised worldwide as robust and well-tested renewable energy technology in the electricity generation sector, preferred because of its efficient energy conversion processes. Modern installations can convert up to 95% of the energy of moving water into electricity. However, the development of hydropower is very site-specific and generally requires a multitude of disciplines during the developmental stages. Hydroelectric installations are exemplary renewable energy converters producing minimal quantities of carbon and other emission gases. Contrary to other processes where water is also an essential ingredient, hydroelectricity generation is entirely non-consumptive.

Energy is the lifeblood of economic and social development worldwide. When considering the current global energy shortages, the emphasis to reduce CO₂ emissions, the development of alternative energy generation methods and the growing energy consumption, it is clear that there is a need to change the way energy is created and used. The demand for energy is increasing continually, and those demands need to be met in order to stimulate worldwide development. Globally energy is derived mainly from fossil fuels, but due to its negative environmental impact, the expansion of fossil fuel as an energy source is being resisted in some cases. Therefore the current generation has to focus on the development of renewable energy sources.

Pump as turbine (Queenswood Reservoir experimental set-up)
Renewable energy is the way forward and the potential for its development indeed exists. Currently hydropower contributes only 3% of global energy consumption, which is a fraction of its potential. Africa is the most underdeveloped continent with regard to hydropower generation, with only 6% of the estimated potential exploited.

South Africa itself is facing an energy crisis, which places additional importance on harvesting all available, feasible renewable energies. Rolling power cuts that hit the entire country at the start of 2008 made all citizens aware of the fact that demand for electricity is grossly outstripping supply.

A Baseline Study on Hydropower in South Africa (BSHSA) (Barta 2002) presents an historical overview of state-of-the-art development of hydropower in South Africa up to 2002. The information collected and processed enabled the formation of a much needed hydropower database for future reference and planning of water resources development.

The amount of power that can be produced at a suitable site is a function of available head and flow (of sustainable quantity) according to the following formula:

\[ P = \rho g Q H \eta \]

where:
- \( P \) = power output (W)
- \( \rho \) = density of fluid (kg/m\(^3\))
- \( g \) = gravitational acceleration (m/s\(^2\))
- \( Q \) = flow rate (m\(^3\)/s)
- \( H \) = effective head (m)
- \( \eta \) = plant overall efficiency (0.95 for modern electromechanical equipment)

Water scarcity concerns are often used to dismiss the potential for hydropower in South Africa. However, in reality, energy derived from extracting the potential energy of elevated water during its descent has an important role to play. This is especially important when one considers the huge volumes of water that are moved around the country in balancing supply and demand, and the fact that the energy content of this water is seldom considered (Banks and Schäffler 2006).

**PAST AND PRESENT DEVELOPMENT OF HYDROPOWER IN SOUTH AFRICA**

By international standards the extensive development of hydropower for electricity generation has not been considered seriously in South Africa, with the exception of the development of several pump storage schemes for peak generation. There are also two storage controlled large hydropower plants situated on the Orange River. At present the overall hydroelectricity generation capacity represents only about 5% of the current 45 500 MW installed generation capacity in South Africa.

Although no significant development of hydropower in southern Africa has been noted for the last thirty years, small-scale hydropower electricity generation has been a significant component of the electricity production in several parts of South Africa, mainly for the urban settlements situated along the eastern side of the Drakensberg Mountains.

The first known small-scale hydroelectric plant was installed in 1885 at the foot of Table Mountain in Cape Town. There are a few surviving old plants still situated around South Africa, but most of them are not in operation. These installations need serious refurbishment and upgrading.

A new small-scale hydroelectric installation was commissioned very recently in the Sol Plaatje Municipality in the Free State, consisting of two separate generating sites with a total capacity of 7 MW.

**NEED FOR RENEWABLE ENERGY DEVELOPMENT IN SOUTH AFRICA**

Although it is acknowledged that South Africa is not particularly endowed with the best hydropower conditions, supplying water over long distances and elevations is common for domestic, industrial and irrigation use. The infrastructure systems which allow daily water transport (tunnels, pipelines, canals, water distribution systems) or environmental water releases (from large and medium dams) are potential sources for small-scale hydroelectricity generation in the South Africa of today.

The development of hydroelectricity, generated from the augmentation of hydraulic structures such as dams and canals, will enable optimal use of available water resources and promote Public Private Partnerships (PPPs).

**WHERE TO LOOK FOR HYDROELECTRICITY IN SOUTH AFRICA**

Refurbishment of existing hydroelectric installations

There are a few existing small-scale hydroelectric installations scattered around South Africa, Lesotho and Swaziland. The overall refurbishment capacity potential is in the order of 15 MW. There are several very small active, or not-in-use, privately owned installations. The districts and/or local municipalities should identify these installations and determine their hydroelectric potential. The funding could be provided by the DBSA (Development Bank of Southern Africa).

**Typical pressure reducing station**

(Queenswood Reservoir)
water supply and distribution: may be found in the following spheres of plants can be installed. Hidden potential under gravity, small-scale hydroelectric generally, anywhere where water flows may be developed along this principle. 1 kW to 1 MW) identified in South Africa, turbine/generator. The pico-, micro- and mini-hydroelectric sites (i.e. capacity from 1 kW to 1 MW) identified in South Africa, may be developed along this principle.

Gravity low- and high-head water carrier systems
Generally, anywhere where water flows under gravity, small-scale hydroelectric plants can be installed. Hidden potential may be found in the following spheres of water supply and distribution:

Irrigation canals
Hydro energy can be extracted from most irrigation canals. To utilise a low-head hydropower source, a horizontal turbine/generator set or even the yesteryear water wheel technology, may be adopted. The water wheel systems can be adapted for canals with flow rates up to 1.0 m³/sec and more, requiring heads between 2 and 7 m, offering typically as much as 50 kW. A series of water wheels may be assembled at any irrigation canal with sustainable flow.

Water utility/municipal water supply/distribution systems
Practically each of the 284 municipalities, and several of the water supply utilities (i.e. former water boards) operating and administering gravity water supply/distribution systems anywhere in South Africa can consider small-scale hydroelectric installation. Most of these water supply/distribution systems, or their sub-systems, may be equipped with pumps as turbines (i.e. reversible flow pumps), replacing the pressure throttling valves and allowing for the generation of hydroelectricity. The hydro-energy may be used locally, or supplied to the national electricity grid or to an isolated electricity demand cluster.

The University of Pretoria’s Department of Civil Engineering, together with Bloem Water, Tshwane Metropolitan Municipality and Ethekwini Municipality as collaborating organisations, is undertaking a Water Research Commission project investigating the potential of generating electricity from water distribution systems.

National inter-basin water transfer schemes
To overcome the imbalances between geographical water availability and demand for water, a number of inter-basin water transfer schemes have been developed in South Africa. To date the government has financed some twenty-six inter-basin water transfer schemes which are administered by the Department of Water Affairs. Practically at all these schemes the small-scale hydroelectricity plants (potential capacity between 0.3 and 10 MW) may be installed at locations where a gravity water supply component (e.g. gravity pipeline) is present. It is estimated that initially some 202 GWh annual electricity output, and reduction in carbon dioxide of some 118 000 tons per annum, can be derived from the national water transfer schemes.

Hydropower in mining
At all deep mines in SA large quantities of water are used for cooling, as well as for powering hydropower drills (i.e. mechanical energy derived from hydropower). Typically, a vast quantity of water is poured down a deep mine daily (a 2 km drop can generate 20 MPa pressure) for cooling and for dust suppression. This water is chilled on the surface in a refrigeration plant and conveyed through insulated pipes to the working areas where it is used in heat reduction and as a powering source for the water rock-drills and jetting guns. Pelton turbines and centrifugal pumps with variable speed drives are popular for hydropower generation in South African deep mines. Several mines can discount their grid electricity demand by generating electricity in-house.

Long diversion-fed hydropower installations
A long feeding canal, pipeline or tunnel can supply a hydropower installation, which will return the water to the same river catchment or to another river catchment. An example of such
Civil Engineering

Storage hydro-plant consists of upper into full load production. A pumped further 15 seconds to get a hydro-plant takes two seconds of starting time and a installations into the network. It typically introducing the pumped storage hydro Electricity supply grid are best satisfi ed by the peaking requirements of the electric South Africa has a proud history of dam building, with the fi rst storage dam built as far back as 1663 at the foot of Table Mountain in Cape Town. In total there are about 3 500 dams of all sizes and types in South Africa. About 450 dams are classified as medium or large dams. It is estimated that some 100 large and medium dams are suitable to be augmented for generation of hydroelectricity by means of a turbine/generator unit attached to existing dam infrastructure (hydroelectric capacity ranging between 0.3 and 3 MW). The dams with best hydroelectricity potential have already been identified and several development proposals are being compiled for submission to the Department of Water Affairs.

Pumped storage hydropower schemes

The peaking requirements of the electricity supply grid are best satisfied by introducing the pumped storage hydro installations into the network. It typically takes two seconds of starting time and a further 15 seconds to get a hydro-plant into full load production. A pumped storage hydro-plant consists of upper and lower dam storage reservoirs. Water is pumped from lower to upper storages when electricity is in low demand, mostly during the night. The upper storage reservoir serves as ideal hydraulic energy storage (battery). Storing 1 kWh of hydro-energy requires 10 m³ over a drop of 40 m.

There are at present three pumped storage hydro schemes (one municipal and two owned by the state) in South Africa. The national electricity utility Eskom is presently building the Ingula PS scheme (four 333 MW pump turbines) costing R16.6 billion.

It must be noted that in South Africa the hydroelectricity produced from the pumped storage installations cannot be considered as ‘green’ because the energy used for the pumping of water is coal-based.

Importing hydroelectricity from other countries in Africa

South Africa could import hydro-energy from other countries in southern Africa, such as Angola, Mozambique, Zambia, and particularly the Democratic Republic of the Congo (DRC) with its Inga Dam Hydro site on the Congo River, offering almost unlimited potential for development of imported hydropower. The Inga Dam Hydro Power Station has a potential capacity output of 45 000 MW (i.e. almost as much as the whole current electricity supply capacity of South Africa). South Africa could have a share in this capacity, if the political and socio-economic circumstances in southern Africa would allow safe transmission of hydro-energy over the long distances involved. If implemented, the monitory contribution and commitments from South Africa would undoubtedly be huge.

NATIONAL SCENARIO FOR IMMEDIATE DEVELOPMENT OF HYDROELECTRICITY IN SOUTH AFRICA

The Integrated Resource Plan (IRP) 2010 called for contributions from all renewable energy sources on how renewable energy resources and technologies, including conventional hydropower, can be developed and implemented over the next thirty years in South Africa. For the purposes of the revised IRP 2010, the following scenario for development of conventional (green) hydropower in South Africa has been concluded:

At present the installed capacity of the conventional (green) hydropower in South Africa stands at 700 MW. It is envisaged that this capacity could be increased by 300 MW by the year 2016 and by 400 MW more before 2020. It is further estimated that a potential of some 1 100 MW would be available for the development of conventional (green) hydropower before 2030. In South Africa the realistic price per one MW of hydroelectricity fluctuates between R15 million and R25 million depending on the type, size and location of the hydroelectric installation, if attached to existing civil infrastructure.

NEW RESEARCH PROJECT: ENERGY FROM WATER DISTRIBUTION SYSTEMS

An initial scoping investigation highlighted the potential of hydropower generation at the inlets to storage reservoirs, i.e. bulk water distribution systems. Although it was a low-budget pilot hydropower generation installation erected at the Queenswood Reservoir (City of Tshwane Metropolitan Municipality), which was not optimised, the initial runs reflected

<table>
<thead>
<tr>
<th>Reservoirs</th>
<th>TWL (m.a.sl)</th>
<th>Capacity (kl)</th>
<th>Pressure (m)</th>
<th>Flow (l/s)</th>
<th>Annual potential power generation (kWh)</th>
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<td>165</td>
<td>1 850</td>
<td>3 278 980</td>
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<td>470</td>
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<tr>
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<tr>
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<tr>
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<td>407 828</td>
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<tr>
<td>Total calculated yearly power generation</td>
<td></td>
<td></td>
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<td>±10 000 000</td>
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</tbody>
</table>

Table 1: Potential hydropower generation capacity at ten reservoirs in the Tshwane Water Supply Area (Van Vuuren 2010)
the benefit and expected return from such an investment (Van Vuuren 2010).

For example, in the Tshwane Water Supply Area, there are a number of reservoirs that receive water from Rand Water at pressures of up to 250 m. Based on very conservative assumptions, the potential yearly hydropower generation at these reservoirs was calculated. Table 1 shows the potential hydropower generation capacity at ten different reservoirs in the Tshwane Water Supply Area.

The conservative estimates in Table 1 are based on various assumptions, such as the fraction of available head that can be used for power generation and the number of generating hours per day, etc (Van Vuuren 2010). These assumptions need to be verified and quantified, and guidelines should be set up for evaluation of potential hydropower sites.

In South Africa there are 284 municipalities and several water supply utilities, all owning and operating gravity water supply distribution systems which could be considered for small-scale hydropower installations. In Gauteng water is pumped from the main Rand Water supply in Vereeniging to Johannesburg, from where it flows under gravity to Pretoria and northwards to the Modimolle area. All reservoirs along the way are therefore fed under gravity supply from reservoirs higher up and further back along the supply system. The net pressure head is a function of the difference in elevation between the supply point and the point where the pipe enters the reservoir, as well as losses along the way. This indicates a large number of reservoirs that have some type of pressure dissipating system at the downstream end of the supply pipe into the reservoir.

As has been mentioned above, these systems currently dissipate the high head at the receiving end through large pressure reducing control valves in order to regulate downstream pressure levels (Figure 2). This is effectively dissipating useful energy. By investigating a way in which this ‘lost’ energy can efficiently and economically be converted into electricity, and installing it in these reservoirs, there is potential to augment the current electricity supply using micro-hydropower.

The planned Water Research Commission research project has the following aims:
- To develop guidelines to identify locations which have potential for hydropower generation.
- To develop an assessment model including a cost-benefit tool.
- To develop a tool for optimisation of the energy generation from a pressurised conduit by evaluating storage volumes, demand patterns, operating cycles and operating life of the control valves.
- To demonstrate the technology by means of full-scale pilot plant installations.
- To provide educational material to illustrate and describe the process.
- To illustrate that the social and environmental benefits of installing a micro-hydropower scheme outweigh the logistical and technical complications.
- To reduce risks and increase investor confidence in this type of micro-hydropower scheme by pointing out the potential benefits and complications.
- To show that the retro-fitting of a scheme onto an existing system is economically viable – the income generated through the sale of electricity and/or carbon credits outweighs the costs involved in the setting up of the scheme.

The primary objective of the research project is to prove the assertion that it is feasible and possible to generate energy from distribution systems. This requires a systematic methodology for the identification and analysis of all the relevant components and processes. Each of the different aspects of a hydropower project will be investigated in detail including:
- Political and legislative procedures to obtain necessary permissions
- Technical aspects and civil works related to turbine selection, generators and transformers, hydraulics and operational aspects
- Environmental considerations
- Social concerns and potential impacts
- Financial aspects, including the costs related to the aforementioned, potential incomes and methods of determining financial viability.

In order to determine the factors that influence the development of micro-hydropower schemes, full-scale test set-ups will be constructed. This will be the crux of the research project, detailing and recording the entire progression of the construction of micro-hydropower schemes (pilot plants). The approach to construct full-scale pilot plants has the advantage of offering a reliable indication of the potential complications and the feasibility of actually implementing these schemes at other reservoirs or closed conduits in South Africa.

Furthermore, a conceptual model for optimum operation of the hydropower generation plant will be developed. Similarly a cost-benefit model will be developed for hydropower schemes, which quantifies all the costs and benefits associated with planning, construction, monitoring, maintenance and operation. This model will be in the form of a useful tool to determine the feasibility of small, mini- and micro-hydropower projects.

Worldwide hydropower is the most established and reliable renewable energy technology. Traditionally, hydropower is used in large dams where the outlet flow is turbined to generate electricity. Due to the exploitation of most large dams where this is economically viable, focus has shifted to the use of small-scale mini- and micro-hydropower as a way to generate electricity.

ACKNOWLEDGEMENT

The planned research project will be funded by the Water Research Commission, whose support is acknowledged with gratitude.

REFERENCES


CIVIL ENGINEERING SOFTWARE
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DatumMate
WGS 84 Datum Conversion of Drawings

WaterMate
Water Reticulation Design and Static Analysis and Time Simulation

AutoTurn
Vehicle Manoeuvre Simulation/Analysis

RoadMate
Urban/Rural Road Design

AeroTurn
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SurfMate
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Hydraulic modelling and field verification on the Withoogte to Besaansklip bulk water supply pipeline

INTRODUCTION
A change in the steady state operating condition of a fluid system, unintentionally by means of the closure of a valve or unplanned pump operational change, or due to system failure, is communicated to the system by pressure waves propagating from the point of origin in the system at which the change in steady flow condition had been imposed. The system attains a new state of equilibrium, after some time, if the change has not reached destructive proportions. The terms “surge”, “water hammer” and “transient flows” are used synonymously to describe an unsteady flow of fluids in a pipe system.

Pressure transients can cause extensive damage to water distribution systems, from catastrophic pipeline failures on the one hand to less obvious or visible (but often more widespread and dangerous) long-term effects like damaged pipeline seals and long-term cyclic fatigue loading on the pipe wall, leading to higher than expected operation and maintenance costs, extended periods of non-functionality, reduction in the service life of the infrastructure, increased water loss and even intrusion of contaminants into the distribution system.

BACKGROUND
The West Coast District Municipality (WCDM) is responsible for the bulk water supply to the southern West Coast region of the Western Cape. The Withoogte to

![Typical RTPM pressure recording](image1)

![Typical RTPM site arrangement illustrating pressure transducer connection at an air valve installation, protective box containing the battery and logger unit, and the GPS receiver in the foreground](image2)
Besaansklip Reservoir pipeline is a strategic component of the bulk supply system. The pipeline conveys water under gravity from the WIT WTW near the town of Moresburg to the Besaansklip Reservoir near the Port of Saldanha over a distance of 62.7 km via a pre-stressed concrete and steel pipeline with diameters varying between 1 100 and 1 500 mm. The flow into the Besaansklip Reservoir is controlled through four remotely operated flow control valves and one bypass connection that always remains open. The normal operating approach is to maintain stable reservoir levels in both the WIT and Besaansklip Reservoirs by continuously adjusting the flow rate into the Besaansklip Reservoir.

The WCDM recently completed a comprehensive leak detection survey as part of a pro-active program to assess the condition of their bulk water supply infrastructure. The investigation was performed by SSIS Sahara (Pty) Ltd (SSISS) using the precise Sahara® leak detection system. During the Sahara inspections on the WIT to Besaansklip pipeline, it was observed that operational changes (opening and closing of valves) were performed at a relatively fast rate. Pressure surges on gravity pipelines are very sensitive to the rate of operational change, and although the existing approach does not subject the pipeline to peak pressures leading to regular pipe failures, it was agreed that it would be very valuable to have a better understanding of the impact that the current operational regime has on the transient pressure behaviour of the pipeline, and whether the magnitude of pressure surges could be reduced by implementing operational changes.

1. Measured pressure variation during similar operating scenarios, with the major system off-takes closed and then open, illustrating the negligible difference in the magnitude of the maximum and minimum pressures
2. Measured versus modelled comparison during a valve closing and opening sequence
3. Measured versus modelled comparison during valve opening and closing at three different locations along the pipeline
4. Modelled pressure variation at different locations along the pipeline following three different valve opening and closing times
5. Reduction in the maximum/minimum pressure amplitude along the pipeline due to an increase in the valve operating time from 30 seconds (red envelope) to 240 seconds (blue envelope)
SSISS was subsequently commissioned to compile a hydraulic model of the Withoogte to Besancklip pipeline in order to mimic the steady state and transient behaviour of the pipeline following various operational scenarios. The hydraulic model was compiled using the Surge 2010 analysis software and calibrated against actual measured pressure data captured on site using Remote Transient Pressure Monitors (RTPM).

REMOTE TRANSIENT PRESSURE MONITORING (RTPM)

In order to calibrate the steady state and dynamic models, actual pressures were measured by RTPM devices. The RTPM records the variation of pressures within a pipeline and has the ability to ‘sense’ the approach of a pressure transient and to automatically increase the rate of data capturing to ensure that the surge event is accurately recorded. The pressure measurement device can therefore be used to measure both static and dynamic pressure variations over long periods.

The system’s features include the following:
- RTPM is portable and easy to operate and install.
- Pressure sensors can operate at any range of pressure, including negative pressures.
- The units feature user programmable recording intervals and transient detection trigger settings.
- The units have GPS receivers to ensure time synchronised logging at all locations along the pipeline.

A typical pressure/time plot is illustrated by Figure 1 and the typical RTPM site arrangement is illustrated by Figure 2.

The RTPM records the variation of pressures within a pipeline and has the ability to ‘sense’ the approach of a pressure transient and to automatically increase the rate of data capturing to ensure that the surge event is accurately recorded.
**PIPELINE PARAMETER VERIFICATION AND HYDRAULIC MODELLING**

The data gathered with the RTPM was used to confirm the following parameters and calibrate the hydraulic model:

- **The impact of system off-takes:** Major off-takes along a pipeline can reduce the magnitude of pressure surges or contribute to a faster dampening of the pressure waves in a system. The data gathered on the Withoogte-Besaansklip pipeline however confirmed that the influence of the off-takes was negligible on this system (Figure 3).

- **Wave celerity:** The GPS synchronised readings at different locations along the pipeline were used to calculate the wave celerity of pipe sections of similar diameters and materials.

- **Steady state hydraulic performance and absolute roughness:** Good correlation was achieved between the measured and modelled steady state pressures with the model predicting pressures to within 5% of the measured values at an absolute roughness value \( k_s \) of 0.35 mm for similar flow conditions. The calibrated model was used to confirm the maximum hydraulic capacity of the pipeline in its current condition, which is important from a long-term planning point of view.

- **Transient behaviour:** Good correlation was achieved between the modelled and measured surge results. The wave

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**Figure 3**

**Modelled pressure variation at different locations along the pipeline with the by-pass on the Besaansklip inlet manifold open and closed**

**Figure 4**

**Modelled pressure variation at different locations along the pipeline following simultaneous rapid valve closure under peak flow conditions with the by-pass on the Besaansklip inlet manifold open and closed**

**Figure 5**

**Maximum and minimum pressure envelopes following simultaneous rapid valve closure under peak flow conditions with the by-pass on the Besaansklip inlet manifold open (blue envelope) and closed (red envelope)**
celerity and transient behaviour of the system were therefore accurately reflected by the Surge 2010 hydraulic model, and the model could be used with confidence to analyse further operational scenarios. Figures 4 and 5 illustrate the correlation between the measured and modelled pressure variation following the execution of similar operational changes in the physical and simulated environments.

**RECOMMENDATIONS**

Using the calibrated hydraulic model, a number of operational variations were modelled to determine its impact on the induced pressure surges. The expected maximum and minimum pressure envelopes along the pipeline were generated to illustrate the maximum and minimum pressures along the entire route to confirm that the maximum pressures did not exceed acceptable values. Some of the operational scenarios which were evaluated are described below:

**Valve operating times**
The impact of increasing the valve opening and closing times was assessed. Figure 6 clearly illustrates the benefit of increasing the valve opening and closing times. Even though short operating times do not result in pressure surges that are higher than the rated capacity of the pipeline under the current normal flow conditions, it is clear that increasing the valve operating time, significantly reduces the extent of pressure variation on the system and therefore reduces the amplitude of cyclic loading (as shown in Figure 7).

**Effect of the open by-pass into Besaansklip Reservoir**
Under current normal operating flows, it was found that the open by-pass connection into the Besaansklip Reservoir did not contribute to a significant reduction in the magnitude of pressure surges. The open by-pass did, however, result in the faster dampening of the pressure waves as illustrated by Figure 8.

**Maximum flow condition – rapid valve closure**
The impact of a rapid and simultaneous valve closure under peak flow conditions, and with the by-pass open and closed, is illustrated by Figures 9 and 10. The high surge pressures that could be generated under peak flow conditions reiterated the importance of implementing strict operating rules to prevent the simultaneous closure of multiple valves.

Based on the surge modelling, recommendations were made with regard to the minimum allowable valve operating times, acceptable time delays between subsequent valve operations, and operational safeguards to ensure that the pipeline is not overstressed, and also to reduce the cyclic pressure amplitude caused by normal operational changes.

**CONCLUDING REMARKS**

“Following the pressure monitoring and hydraulic modelling of the Withoogte-Besaansklip pipeline, we now have a much better understanding of the hydraulic performance and behaviour of this pipeline and the impact of operational changes on the system. We can now also investigate the impact of any operational change and demand variations on the system with confidence.”

So says Nic Faasen, Manager: WCDM Water (bulk water service provider to 22 towns in the West Coast).
Design of water reticulation network configuration and public standpipes

BACKGROUND
As South Africa embarks on massive infrastructure development, especially in the water sector, there is a need for quality control of designs that are being put up for construction of water supply projects. Water is a scarce commodity in South Africa and needs to be utilised efficiently and wisely. Thus designs must aim at supplying water to a large number of planned users where a reliable source of water is located. This article highlights the invaluable resources that are available to design engineers involved in water supply projects in rural areas, and emphasises the enormous benefits that can be derived from a looped network configuration when selected in the design of a reticulation system over an entirely branched network configuration. It also highlights points that are necessary in the design of public standpipes.

RESOURCES FOR DESIGNING WATER SUPPLY SYSTEMS
The following documents are useful in designing water supply systems in South Africa:
■ SANS 1200: Code of Practice for the Design of Civil Engineering Services

The Red Book is available at no cost at the website (www.csir.co.za) of the Council for Scientific and Industrial Research (CSIR) and the Department of Water Affairs guideline is also available at their website (www.dwa.gov.za), also free of charge. The SANS 1200 can be purchased from www.sabs.co.za.

The foreword to the Red Book encourages readers to use it, discuss it and debate the guidelines it contains. The purpose of the updated 2004 version of the DWA guidelines is primarily to pass on to local government the experience of national government in the development of water and sanitation services, especially in the planning and design of water and sanitation infrastructure. The SANS 1200 contains the Standard Specifications for Civil Engineering Construction which forms part of contract documents.

NETWORK CONFIGURATIONS
Some reticulation networks meant to supply water to a large area, such as a regional scheme, have been designed entirely with a branched network configuration. It usually consists of a long bulk pipeline which supplies water to a series of reservoirs, which in turn supplies water to various villages through a reticulation network that branches into the villages and delivers the water to users through public standpipes. There is thus only one possible path from the source to the standpipe. Such a network, though less expensive, can have the following problems:
■ Low reliability
■ Potential danger of contamination caused by large part of network being without water during irregular situations (Figure 1)
■ Accumulation of sediments due to stagnation of the water at the system “dead” ends, occasionally resulting in taste and odour problems
■ Future extensions which may cause pressure problems
■ A fluctuating water demand producing rather high pressure oscillations.

A looped network can overcome the above-mentioned problems, and offers a number of advantages, including the following:
■ Water in the system flows in more than one direction to get water from the source to the standpipe, and long-time stagnation does not occur as easily anymore.
■ During system maintenance, the area concerned will continue to be supplied by water from other directions (in case of a pumped system, a pressure increase caused by restricted supply can promote this).
Water demand fluctuations will not produce a significant effect on pressure fluctuations.

Extensions to new developing areas, as well as ensuring adequate pressure and flow, can be achieved more easily. Most water supply systems are complex combinations of loops and branches, with a trade-off between loops for reliability and branches for infrastructure cost savings. In systems such as rural reticulation networks, the low density of customers may make interconnecting the branches of the system prohibitive from both monetary and logistical standpoints. The design engineer, in such a situation, must weigh the options and choose a balanced, combined network configuration which gives best value for money.

PUBLIC STANDPIPES

The public or communal standpipes are those installations through which the public and the community/village have access to water. Some public standpipes have been constructed without a platform. In other instances there is a platform that measures just about 1 m² in area and the stand post is not strong enough to withstand a cow rubbing her itchy body against it. This situation is not desirable, as there is no proper drainage at such standpipes, and when they are damaged, precious water is lost.

The Red Book states that the design of the standpipe installation requires careful planning, and that special attention should be given to drainage of excess water and avoiding wastage, in order to minimise health risks. Bearing this in mind, standpipes can be designed to have watering troughs so that stray animals would not need to lick water from the taps and platforms, thereby contaminating them.

A drain and a soak pit are also required around the platform to collect and convey the excess water. A suitable slope over the top of the platform is also worth considering.

Furthermore, where household water has to be fetched and transported, mostly by women, an overhead spout can be included so that there is no need for another person to assist her in lifting the container onto her head. A ramp to cater for physically challenged individuals who have to fetch water on their own can be factored into the design.

CONCLUSION

Our friends and family living in the rural areas are dependent on, and deserve, the planned infrastructure development mentioned at the start of this article. The design of rural water reticulation systems must therefore be such that the level of service is as dignifying as anywhere else in the country. Designs should be sustainable, reliable and durable, and should make a positive difference in their lives.

REFERENCE


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Web: www.hall-longmore.co.za
Northdene Tunnel Pipework Replacement

BACKGROUND
The existing Northdene Tunnel was constructed circa 1927 as part of Durban’s very first large water supply from Shongweni Dam to the Northdene Filters. However, Durban’s water requirements grew and changed over time, and the water supply from Shongweni eventually became too small to be cost-effective.

When a new water treatment works was constructed at Durban Heights the tunnel was re-used for the Southern Aqueduct by laying a new DN900, “VJ” coupled steel pipe through the tunnel to supply water to the southern areas of Chatsworth and Umlazi. The water demands increased dramatically, however, and in the late 1990s a parallel DN1000 continuously welded steel pipe had to be pulled through the tunnel as an emergency measure to provide additional water supply capacity to Durban’s southern areas.

The tunnel barely accommodated these two pipes, and the lack of working space made maintenance or repair of either of the pipes virtually impossible. This posed a significant risk to the continuous supply of water to the southern areas of Durban, and a solution needed to be found.

PROJECT DESCRIPTION
Ethekwini Water & Sanitation (EWS) appointed SSI Engineers to design and
manage the replacement of the DN900 and DN1000 pipes with a single DN1600 steel pipe in the tunnel, and to replace a 40 m long section of old DN900 “Socea Bonna” pipes (Prestressed Concrete Cylinder Pipe – PCCP) outside the tunnel. A fundamental requirement was that the water supply to the southern areas of Durban should not be disrupted.

The site is severely constrained by various obstructions and impediments, and careful planning was required to ensure the continuous supply of water in the Southern Aqueduct. Before the pipes in the tunnel could be replaced, a bypass pipe had to be installed, in parallel to the tunnel, to maintain the flow of water. This necessitated the construction of a jacked sleeve, approximately 120 m long, through which a DN1400 steel bypass pipe could then be laid. The jacked sleeve passes under the main Durban – Johannesburg railway line, as well as Main Road, and no disruptions were allowed to the movements of trains or motor vehicles. Frequent specialist levelling surveys were carried out on the rails to check that the jacking operations did not affect the rail supports, which could cause derailment of passing passenger and freight trains.
The project consisted primarily of the installation of a bypass pipeline in parallel to the pipes in the tunnel, removal of the existing pipes from the old Shongweni tunnel, installation of the new pipeline in the tunnel, replacement of approximately 40 m of DN900 “Socea Bonna” prestressed concreted cylinder pipes outside the eastern portal, construction of interconnecting pipework, valves and various modifications to and construction of new reinforced concrete valve chambers on both sides of the jacked sleeve.

The project was divided into three separate contracts, namely:

- Contract 1: Pipe Jacking (awarded to Jacked Pipelines)
- Contract 2: Pipe Supply (awarded to Hall Longmore), and
- Contract 3: Pipe Installation (awarded to Esorfranki Pipelines).

The installation of the pipeline was severely complicated by the confined working spaces, particularly on the eastern side of the tunnel. The contractor had to work beneath one of the largest electricity pylons in Durban. Height restrictions and access problems made the handling and installation of the new DN1600 and DN1400 pipes extremely difficult. The risk of damage to the pylon was an ever present threat, and special precautions had to be observed continuously to prevent catastrophic consequences if the support structure or the foundations were damaged.

In addition, leaking pipes (old “Socea Bonna” PCCP pipes) and groundwater posed further problems, to the extent that the contractor continually had to deal with water inside the trenches and on the working areas adjacent to the trenches. The DN1400 pipes for the bypass pipeline were welded together outside the jacked sleeve, and then incrementally winched into the sleeve. The DN1600 pipes were winched individually into the tunnel and welded internally. The pipes within both the sleeve and the tunnel were grouted up with a flowable cement grout, and cores were taken to check that the uncoated steel pipes were fully covered for corrosion protection. Circularity of the pipe had to be maintained during installation, and special attention was paid to prevent flotation of the pipe during grouting operations.

CONCLUSION

The project was completed in May of this year, without a single interruption in the Southern Aqueduct bulk water supply to Chatsworth and Umlazi.

PROJECT TEAM

Client
Ethekwini Water & Sanitation
Project Manager: Andrew Copley

Contractors
Esorfranki Pipelines (Pty) Ltd
Jacked Pipelines
(a division of WK Construction)
Hall Longmore

Consultant
SSI Engineers and Environmental Consultants (Pty) Ltd
Project Manager: Darren van Rooyen

Sub-Consultants
Environmental:
Environmental Planning & Design
Engineering Survey: JC Martin Surveys
Geotechnical: Moore Spence Jones

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Complications of multi-channel hydraulic modelling

A case study: the proposed upgrading of bridges across the Orange River near Keimoes by SANRAL

BACKGROUND

SANRAL (South African National Road Agency Limited) awarded a tender to BKS (Pty) Ltd for the design and implementation of the widening of the R27 bridges crossing the Orange and Sout Rivers (near Keimoes, as shown in Figure 1). Prof Fanie van Vuuren and Marco van Dijk from the University of Pretoria were commissioned to undertake a detailed hydrological and hydraulic assessment of the Orange River at the sites where the bridges near Keimoes had to be improved. The project involved the widening and possible raising of four single-lane structures near Keimoes to handle a design flood based on a specific recurrence interval.

The Orange River is South Africa’s largest river and, through various transfer schemes, is used for irrigation, and domestic and industrial needs along the river and in adjacent catchments. The impoundments also contribute to hydropower generation and create the ability to manage the flood attenuation requirements by controlled releases. The stretch of the Orange River in the vicinity of the town of Keimoes in the Northern Cape Province can be described as an extensive braided river channel. Kanoneiland, the largest island system in the Orange River, is located roughly 20 km upstream of Keimoes, and the Neusberg Weir is situated approximately 25 km downstream of Keimoes. Just downstream of Kanoneiland the main river channels divide into an even more heavily complex

Table 1 Characteristics of the gauging stations up- and downstream of Keimoes

<table>
<thead>
<tr>
<th>Hydro no</th>
<th>Place</th>
<th>Effective catchment area* (km²)</th>
<th>Period of usable data</th>
</tr>
</thead>
<tbody>
<tr>
<td>D7H002</td>
<td>Bridge at Prieska</td>
<td>274 396 (336 348)</td>
<td>1971-07 to present</td>
</tr>
<tr>
<td>D7R001</td>
<td>Boegoeberg Dam</td>
<td>279 088 (341 693)</td>
<td>No DT</td>
</tr>
<tr>
<td>D7H008</td>
<td>Weir just downstream of Boegoeberg Dam</td>
<td>279 090 (341 695)</td>
<td>1932-10 to present</td>
</tr>
<tr>
<td>D7H005</td>
<td>River section (Upington)</td>
<td>288 776 (363 031)</td>
<td>1974-07 to present (low flow DTs for 1942-10 to 1974-07)</td>
</tr>
<tr>
<td>D7H014</td>
<td>Neusberg ‘weir’</td>
<td>293 126 (367 381)</td>
<td>1993-07 to present</td>
</tr>
<tr>
<td>D7H003</td>
<td>Bridge at Kakamas</td>
<td>293 406 (367 661)</td>
<td>1965-10 to present</td>
</tr>
</tbody>
</table>

Note: * The total catchment area is given in brackets as obtained from WRSM2005
and braided river reach. Upstream of the R27 road crossing, the Orange River is less braided, creating four main river channels. Dense bank vegetation (trees and reed beds) protect and stabilise the banks during flood events. At Neusberg the Orange River drains a total catchment area of nearly 370 000 km², i.e. nearly 30% of the total surface area of South Africa.

The creation of various storage facilities in the Orange and Vaal River Systems (Gariep, Van der Kloof, Vaal, Katse, Bloemhof, Mohale, Grootdraai, Kalkfontein, Erfenis, Allemanskraal and Sterkfontein Dams) has changed the flood characteristics at the project site. The historical flow records at Neusberg (D7H014), Kakamas (D7H003), Boegeoeberg Dam (D7H008) and Upington (H7H005) were reviewed and relationships were established to correlate the flow at the different gauging stations, and to obtain a flow record for the sites at Keimoes.

ASSessment of the Historical Flood Data

The hydrological review required a quantification of the probability of inundation and determining of the flood peaks for the design recurrence intervals. It is common knowledge that the confidence of flood frequency is influenced by the length of the reliable data record and hence ‘as long as possible’ flow records are needed to improve the reliability of any flood prediction. In the Orange River downstream of the Vaal river confluence a number of flow gauging stations exist. Table 1 indicates some characteristics of the gauging stations.

The low incremental flow contribution between selected consecutive gauging stations in the Orange River, as well as the flow magnitude and time-based flow variation in the Orange River, facilitate the interchangeability of the flow data of such gauging stations. Neusberg Weir (D7H014) and Kakamas Bridge (D7H003) just downstream of Neusberg, are two such gauging stations. It can therefore be assumed with a high degree of confidence that the flood peak record of the one can be used for the other, because the flow records are for practical purposes similar (Van der Spuy 2008).

Review of the discharge rating curves to be used in the assessment of the flow at the Keimoes bridges

The various flow records for the different gauging stations, as listed in Table 1, were compared and correlations obtained to enable the compiling of a representative flood record at Upington and Kakamas Bridge. The procedure for this process was to use correlations between gauging stations, filling in gaps in the data sets and overall improvement of the discharge tables at the stations in this river section to compile annual flood peak records.

Table 2 Proposed design floods based on data from D7H005 (Upington)

<table>
<thead>
<tr>
<th>RI (years)</th>
<th>1:2</th>
<th>1:5</th>
<th>1:10</th>
<th>1:20</th>
<th>1:50</th>
<th>1:100</th>
<th>1:200</th>
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<tr>
<td>Q (m³/s)</td>
<td>1437</td>
<td>2994</td>
<td>4212</td>
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<td>7369</td>
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Figure 2 provides a pictorial view of the natural section at Upington (D7H005), which is used as the gauging section.

**Flood frequency analyses**

Table 2 reflects the proposed design floods based on the flood frequency distribution functions for the data at Upington (D7H005). Figure 3 reflects the statistical flood peak assessment for the data at Upington (D7H005).

**Flood management by DWA in the Orange–Vaal River System**

Real time recordings of rainfall and runoff provide valuable input into the effective operations of the dams to reduce the flood peaks. Vaal Dam, with multiple crest gates, provides for flood management, while the Gariep and Van der Kloof Dams in the Orange River have uncontrolled spillway sections. The Regional Offices of the DWA (Department of Water Affairs) are responsible for the management of local floods in their administrative regions, while the Directorate Hydrological Services of the Department’s Head Office is responsible for flood management in the Vaal and Orange River System. The emphasis is on the optimisation of yield from the dams and minimising the flood peaks.

In the lower Orange River there is enough time between the storm event and the arrival of the flood for early flood warning, which is also of importance during the construction phase of the project.

**REVIEW OF THE STAGE–DISCHARGE RELATIONSHIP NEAR KEIMOES**

**Flow measurement**

Low flow gauging was performed (± 21 to 70 m³/s) at two gauging sites in the main stream (northern stream) and in the southern stream. A 1.5 MHz Sontek Acoustic Doppler Profiler was used to perform the velocity measurements along a suspension tagline across the canals. The flow measurements indicated that the flow distribution between the main and southern channel is an approximately 75:25 split.

**Stage flow gauging**

Seven measuring plates were installed up and downstream of the bridges at Keimoes. The positions of these measuring plates are shown in Figure 4. Readings were taken twice weekly for four months (December 2008 until April 2009). The flow data from the Upington and Neusberg gauging stations were used, as well as the estimated traveling times to determine the flow rate associated with the recorded water levels at the gauge plates. The flow during this period varied between 44 and 1 026 m³/s.
Fly ash promotes a more harmonious relationship between design and engineering. Form no longer has to follow function.
These water level recordings reflected the flow characteristics of the river system, indicating that for similar flow rates, the water levels obtained on the rising limb of the flood hydrograph, and the falling limb, were different. This confirmed the intuitive understanding of the variation of roughness in river sections overgrown with reed beds and thick bank vegetation. It was found that the water level in the southern channel is usually higher than the flow in the main stream by between 0.4 to 0.7 m for the low flows. The opposite, however, occurs during the higher flows that were measured where the main stream water level was between 0.8 and 1.0 m higher than the southern channel.

The recent floods of February 2010 and January/February 2011 resulted in some of the bridges at Keimoes being overtopped. This flood data was used to re-calibrate the numerical model for the following flood peaks:

- A peak discharge of 3 288 m³/s on 8 February 2010
- A peak flood of 5 470 m³/s on 14 January 2011 (Figure 5)
- A flood of 5 079 m³/s on 2 February 2011

A visual recording was made, and the date, time and water levels were recorded at

- Hydraulic gradeline of surveyed water level and high-water mark (main channel)
- Hydraulic gradeline of surveyed water level and high-water mark (southern channels)
- Schematic longitudinal section of bridges across the southern channel
- Existing Bridge B2461 (southern channel)
the bridges during the floods of January and February 2011, which overtopped the bridges across the southern and main channels (B2461, B2462 and B2463). Figure 6 illustrates the recorded water levels at the bridges during these high floods.

**Surveyed hydraulic gradelines**
A hydraulic gradeline was plotted based on the surveyed water levels up and downstream of the site. This was compared with the natural bed slope of the river. Graphical representations of the hydraulic gradelines representing the water surface level for a ± 5–6 km river section is shown in Figures 7 and 8 for the main channel and southern channels respectively. This is shown for the maximum observed flow of 5 470 m³/s (high-water mark) and the water levels during the day of the survey (21 January 2011) when the flow was equal to 3 340 m³/s.

**BRIDGE STRUCTURES**
The overall objective of the proposed construction project is to increase the capacity and improve the safety of
Sections 10 and 11 of the R27 National Route between Kenhardt and Keimoes in the Northern Cape, for the following main reasons:

- To accommodate existing and future traffic volumes without the current delays, which are being caused by having to wait for approaching traffic at the four single-lane bridges across the Orange River and nearby tributary.
- To increase the flood capacity of two of the bridges to an acceptable level, thereby improving safety for the travelling public and reducing the time that landowners and communities are isolated during major flood events.
- To address safety concerns for cycle and pedestrian traffic.

Lifting the two southern bridges will not only provide a supply and escape route during flood events, but the widening of the bridges will streamline traffic across the bridges, particularly during the grape harvesting season when many heavy vehicles use these (currently single-lane) bridges. SANRAL undertook, in consultation with the local farming community, to widen the bridges to two lanes with road shoulders. Sidewalks will also be provided for the many pedestrians.

An in-depth heritage study, which formed part of the Environmental Authorisation process, was performed on these structures. This study established that the three arch bridges collectively known as Grobler’s Bridges were built between 1931 and 1933. The following is a brief summary of pertinent information provided in the comprehensive Basic Heritage Impact Assessment:

During the early 1920s farming activity in the area was well established and grapes, along with other fruit and vegetables, were produced in enormous quantities. While the river was the life
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blood for these activities, it was also a huge economic impediment as there were no bridges across the river able to carry the large loads. The farmers relied on fording the river during low-flow conditions or using pontoons, but it did happen that for several months a year entire island communities were marooned due to floodwaters. The need for adequate bridges was pressing and, after petitioning the government over a number of years, a bank loan was eventually raised by the Divisional Council in 1931 to construct the bridges. A tender call was advertised in February 1932, and some 14 companies responded, of which the new Cape Town company, Murray & Stewart (Pty) Ltd, offered the most competitive bid. These were the years of the great depression and construction methods adopted were labour-intensive, using local materials as far as possible, to enhance employment opportunities in the local community. A huge flood that took place in 1925 largely informed the design, and it would appear that the design engineer was fully aware that the bridges would overtop and built them accordingly with light removable railings. The completed bridges have withstood the test of time, but improvements are now necessitated by vehicle and pedestrian capacity requirements, as well as by the limited flood capacity of Bridges B2461 and B2462.

The study concluded that the improvement of the bridges has distinct economic advantages, but that concerns exist with respect to retaining the heritage qualities. However, the following approach, adopted in the design of the improvements, was considered acceptable:

- Retain as much of the original fabric of the bridges as possible, which includes the widening of B2463, instead of demolishing it, which would be more economical. The other two bridges have to be replaced at a higher elevation, as noted above, to ensure acceptable flood capacity for crossing.

Recalibrated model results (Analysis D) – water surface levels in main channel – cross section 8b to 3 (Bridge B2463)

Overtopping of B2463 (14 January 2011, 5 470 m$^3$/s)

Cross sectional view of Bridge B2461 (southern canal)
Ensure that the form of the original bridges is acknowledged by using a similar arch configuration and similar detailing.
Provide a stopping area, with information boards describing the historical significance of the bridges, on the northern (Keimoes) side of B2463.

**HYDRAULIC ANALYSES**

The hydraulic modelling of a complex river stretch, consisting of a number of channels and subdivisions, has to be based on a good understanding of the hydraulic behaviour under different flow rates in the system. Detailed cross-sectional surveying at a number of positions (some shown in Figure 12) in the study area was also undertaken to allow for the setting up of a hydraulic model.

**Calibration of roughness parameters**

In order to calibrate the model the roughness parameters were varied along each cross section. The model roughness was adjusted to reflect similar water levels as those observed. A complication was that in the Orange River the roughness decreases with an increase in flow and depth, typical for large river systems. The modelling software allowed the changing of the roughness factor with change in flow, i.e. flow depth.

**Numerical modelling**

The public domain and internationally accepted software package HEC-RAS (version 4.1.0) developed by the US Army Corps of Engineers was used to hydraulically model the river system.

Six different analyses were conducted:

- **Analysis A** represents the hydraulic modelling of the system without and with the existing bridges at Keimoes.
- **Analysis B** represents the system after it had been calibrated (initially only based on flow measurements and a four-month flow gauging period in 2008/09).
- **Analysis C** represents the hydraulic modelling of the upgraded bridges crossing the southern streams, raising Bridge B2461 by ± 1.8 m and Bridge B2462 by ± 2.0 m.
- **Analysis D** was conducted containing the existing bridge structures, and the model was recalibrated using the additional 2010 and 2011 flood data, as well as hydraulic gradeline surveys performed in 2011.
- **Analysis E** utilised the recalibrated model constructed in Analysis D and investigated the impact of the upgrading of the bridges as originally planned in Analysis C.
- **Analysis F** utilised the recalibrated model constructed in Analysis D and investigated the impact of the upgrading of the bridges to a revised design level (raising Bridge B2461 by ± 2.3 m and Bridge B2462 by ± 2.5 m).

Figure 13 shows the modelled water levels compared to the surveyed water levels on 21 January 2011, as well as the high-water mark levels. The reference to **WS Survey 2011a** in Figure 13 refers to the modelled water levels for a flow of 3,340 m³/s for 21 January 2011, and **WS Survey 2011b** refers to the modelled water surface of the peak flood (5,470 m³/s). The reference to **Table 3** Summary of modelled water surface levels

<table>
<thead>
<tr>
<th>Channel</th>
<th>Bridge</th>
<th>Water levels (m) upstream of bridges for different RI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1:5</td>
</tr>
<tr>
<td><strong>Main</strong></td>
<td>B2463</td>
<td>723,44</td>
</tr>
<tr>
<td></td>
<td>Existing – B2461 &amp; B2462</td>
<td>723,87</td>
</tr>
<tr>
<td><strong>Southern</strong></td>
<td>Upgraded to current design proposal – B2461 &amp; B2462</td>
<td>723,14</td>
</tr>
<tr>
<td></td>
<td>Upgraded to current design proposal plus 0.5 m – B2461 &amp; B2462</td>
<td>723,14</td>
</tr>
</tbody>
</table>

Note: * No change due to fixed flow distribution utilised in the model (± 25:75 for southern and main channels)

A huge flood that took place in 1925 largely informed the design, and it would appear that the design engineer was fully aware that the bridges would overtop and built them accordingly with light removable railings. The completed bridges have withstood the test of time, but improvements are now necessitated by vehicle and pedestrian capacity requirements, as well as by the limited flood capacity of Bridges B2461 and B2462.
Civil Engineering

The proposed upgraded bridges across the southern canal, as per the current design proposal, which is to raise Bridge B2461 and Bridge B2462 by approximately 1.8 m and 2.0 m respectively, will provide sufficient hydraulic capacity to prevent overtopping of the structure for the 1:20 year flood. However, the lowest shoulder breakpoint level on the bridge is 725.4 m, whilst the highest is 725.9 m and thus, although not overtopping, the 1:20 year flood will inundate a section of the road. The raising of the bridges in the southern channel reduces the upstream water levels for the lesser recurrence interval floods. The raising of the bridges, as well as the bigger approaches, results in a small increase in damming levels upstream thereof for the 1:20 RI flows and higher floods.

In Analysis F above the two bridges across the southern channel were raised a further 0.5 m.

Comparing the results of Analyses E and F it was clear that the raising of the bridge by a further 0.5 m reduces the 1:20 year RI flood level upstream of the bridges, but results in slightly higher damming levels for the higher recurrence interval floods. The total impact of these two bridges on the 1:50 and 1:100 year RI water levels would result in an increase of the upstream water levels in the southern channel with respect to the current conditions of approximately 0.2 m. This is substantially less than the generally accepted norm of 0.6 m. The impact on the upstream water surface levels at the bridges is summarised in Table 3.

REMARKS / CONCLUSION

The hydrological and hydraulic analyses included the:

- Review of historical flow records to generate a flood frequency distribution at Keimoes (Table 3).
- The determination of the flood peaks in the Orange River which will overtop the existing bridges at Keimoes (± 3 150 m³/s for B2461 and B2462, ± 5 350 m³/s for B2463).
- Use of stage-discharge data, as well as a survey of the hydraulic gradeline of the river to calibrate the numerical model by varying the roughness parameters, for the flow ranges 40 to 5 500 m³/s.
- Quantifying of the roughness parameter, which decreases with an increase in flow rate and depth in this part of the braided river section. It was also found that this river system’s roughness and flow distribution between the different braided channels are sensitive to antecedent higher flows.

It was also established that:

- There could be a hydraulic control in the river system between two selected cross sections which, depending on the roughness parameter and river geometry, could only start functioning as a control once a certain flow rate is achieved.
- Flow measurements are required to obtain the flow distribution in the various channels in a braided river system when performing one-dimensional hydraulic modelling.
- The selection of the cross section positions in a braided river system for one-dimensional modelling can be disconnected for each river stream, for example cross section 8b (Figure 12) spilt into two separate cross sections at suitable locations for the main and southern channels. This complicates the calibration of one-dimensional hydraulic modelling.
- The hydraulic gradelines should preferably be determined from level recordings at different cross sections for different flow rates to enable accurate calibration of the hydraulic model.
- The flow data provided valuable information for construction and design related decision-making processes.

REFERENCES

The list of references is available from the editor.
masters of construction

Setting the benchmark in construction Esorfranki has mastered a wide range of services including geotechnical, civils, roadworks and specialist pipeline construction. Esorfranki operates in South Africa, sub-Saharan Africa and the Indian Ocean Islands. QUALITY IS OUR FOUNDATION.
SOUTH AFRICAN DAM INFRASTRUCTURE

Dams play a very important role in the development and management of South Africa’s water resources. Future dam construction is therefore planned as part of the general infrastructure development in South Africa. South Africa in fact has a large investment in dam infrastructure and this infrastructure needs regular maintenance and periodic rehabilitation. The recent SAICE infrastructure report card highlights that there has been some improvement in the quality of dam infrastructure, but that it is still not at a satisfactory level. The Department of Water Affairs has a major programme under way in this respect.

SANCOLD GOVERNANCE STRUCTURE

The South African National Committee on Large Dams (SANCOLD) changed its governance structure in September 2008 to be more democratic and representative of the broader dam industry. The transition from the previous corporate-based system to the new dispensation will be completed at the end of 2011 after the Management Committee elections have taken place. SANCOLD activities cover both “large” and “small” dams, as well as tailings dams. Our chairperson, Danie Badenhorst, served on an ICOLD (International Commission on Large Dams) Committee on Small Dams for several years, and a report on the subject is to be approved at the forthcoming ICOLD Annual Meeting in Lucerne in June 2011.

This report will have high relevance in South Africa where we have a larger number of “small” dams compared to “large” dams.

SANCOLD membership provides organisations and individuals with various opportunities for interaction with other persons involved in water resources management. Two membership categories are now available, namely:

- Corporate membership
  (2011 Membership fee R3 000)
- Individual membership
  (2011 Membership fee R300)

The form for membership application is available on the SANCOLD website.

ICOLD 2012 CONGRESS

SANCOLD represents South Africa on ICOLD and we are represented on a number of its Committees. ICOLD is to hold its 24th Congress in Kyoto, Japan, in 2012. It is really gratifying that we have had offers for 16 papers from South Africans for this Congress – this is a record response. The four topics which will be discussed at the Congress are:

- Environmentally friendly techniques for dams and reservoirs
- Safety
- Flood discharge
- Ageing and upgrading

South Africa hosted ICOLD events in 1978 (Cape Town, Executive Meeting) and 1994 (Durban, Executive Meeting and Congress). The SANCOLD Management Committee has decided to bid for the hosting of the 2016 ICOLD Annual Meeting. The vote on this will take place during the 2014 ICOLD Meeting. If we are successful, it will be a wonderful opportunity for persons in South and southern Africa to interact with the international dam community. The second phase of the Lesotho Highlands Water Project will be under way at the time and should attract a lot of interest from the international attendees.

SANCOLD BIENNIAL CONFERENCE

SANCOLD will be holding its Biennial Conference from 8 to 10 November 2011 in Midrand. The theme for the conference is Management and Design of Dams in Africa. SANCOLD invites all from Africa and the wider family of ICOLD to participate in the conference, which will include technical presentations, a technical visit, and an exhibition. The detailed Conference arrangements are available on the SANCOLD website. The Conference will earn attendees CPD credits. The SANCOLD Annual General Meeting will be held during the Conference period. The SANCOLD Management Committee has decided to hold the annual election via e-mail, as it gives the greater membership an opportunity to participate.

Technical visits to the Bospoort and Rust de Winter Dams have been arranged for Wednesday 9 November. Both these dams have recently undergone major rehabilitation work to meet current dam safety requirements. Rehabilitation work is often of a greater complexity than designing and constructing a new dam, as the existing dam still has to perform its functions while rehabilitation is in progress.

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Tony Murray succeeded in giving a delightful account of this great South African civil engineer and the practice he founded. Anybody interested in civil engineering will find this beautiful publication, with its many photos of dams, hydroelectric and water and waste water schemes, pumped storage schemes, bridges, road projects and many well-known characters/’legends’ fascinating. It reads almost like the ‘Who’s who’ of civil engineering in South Africa and could also be regarded as a coffee-table book.

This publication is simultaneously the history of the man, Ninham Shand, and his company, encompassing projects, as well as the people responsible for them. Ninham Shand was a firm supporter of professional bodies. “He believed that involvement in such bodies was not only the privilege of those whose careers had blossomed. Young engineers were encouraged to serve on committees and hold office soon after graduating as he believed this would assist in developing their all-round abilities.”

For the modern reader Ninham Shand’s 1946 SAICE Presidential Address gives “…. some insight into the breadth and depth of his interests and clarity with which he perceived solutions to burning issues. He is concerned that the profession is inarticulate. He exhorts student engineers not only to acquire technical knowledge, but also to take an active part in the institutions of which they are members and to learn to express their views in everyday language. In this way, he believes, engineers will develop the qualities necessary to influence their fellow men – a task as essential as the application of technical knowledge.” This sounds familiar, especially today.

Ninham Shand used new words to reiterate some of his key points: “In particular he emphasises that engineers must not separate short-term planning from longer-range issues. The engineer should take the initiative in advocating and carrying out systematic planning.” These points made more than sixty years ago are still relevant and often discussed wherever engineers meet.

Port Elizabeth already lacked adequate water supply and in 1948 Ninham Shand proposed the construction of a dam on the Kromme River to augment this supply. Much later his son, Mike, proposed a more appropriate site 20 km downstream of the Churchill Dam on the Kromme River, and construction on the Elandsjagt Dam (now Impofu Dam) started in August 1979.

Ninham Shand had exceptional talent, insight and principles. He was innovative yet conservative; bold but reliable. He was professional, ethical and dedicated. “There must be very few people in this country who have not been affected by a Shands work, one way or another.” However, “There is perhaps nothing that sheds greater light on Ninham Shand, the man and the engineer, than the fact that to all the older and the important people in his profession, and to so many of his clients and colleagues, he was simply ‘Ninham’.”

The story of the growth of Ninham Shand, the firm, from a ‘one-man band’, and its expansion across South Africa and abroad, its personnel over many years, the many project highlights, and of course “LESOTHO – THE CROWNING ACHIEVEMENT”, make for thrilling reading.
Market Contribution

Cosmo City
Sustainable Social Housing

At the time of its proposal more than a decade ago, the Cosmo City housing development was seen as a pioneering prototype for the post-1994 challenges to redress urban spatial inefficiencies in South Africa. In part, this was to be achieved through an overhaul in the country’s legislative and policy framework for land-use planning.

The project was considered a benchmark for a new model to low-cost housing that aimed to create integrated and mixed land use closer to urban and transport centres, rather than on the metropolitan edges, which effectively reinforce marginalisation and poverty.

In 1996, the Northern Metropolitan Local Council (now the City of Johannesburg), in the preparation of its Land Development Objectives, identified the need to provide housing for two large informal communities – Zevenfontein and Riverbend. These informal settlements were characterised by substandard living conditions with limited access to basic services.

Mixed-use Planning

The idea was to relocate the communities onto land that would be earmarked on the basis of access to economic opportunities and public transport in a mixed-income and mixed-use development.

A public and private sector partnership with strong community involvement and buy-in was seen as a way to facilitate a better balance between social responsibility and financial sustainability for the long-term success of the housing development.

After identifying land for public use, the City of Johannesburg had to use existing legislation to appropriate the 1,200 hectares upon which Cosmo City would be built. A protracted period of legal and consultative processes preceded the eventual development framework and technical studies for the project.

By 2000, the now City of Johannesburg and the Gauteng Department of Housing, invited tenders for development proposals for Cosmo City – with its location northwest of Randburg.

A team headed by Basil Read and Kopana Ke Matla were the successful bidders, and together they formed a company called Codevco. They then pulled together the expertise of professional teams, including consulting engineers KV3, now known as WorleyParsons RSA.

The final go-ahead for the project was given in October 2004 and the pegging of the first phase began in November of the same year. Construction on the infrastructure and services started in January 2005, and the first beneficiaries took occupation of their homes in November 2005.

Integrating Housing Typologies

One of the key objectives at the time of planning the Cosmo City project was to bring together people of different income groups that would be living in the same area. The intention was to achieve this through the provision of different housing tenure and price types in the same area, linked through schools, crèches, clinics, transport, parks and public spaces.

“The integrated approach means bringing different housing typologies in one area together, yet creating some demarcation with the use, for example, of streams or natural wetland areas so that the respective property values remain intact,” says Marius Kannenberg, Technical Director at WorleyParsons in Randburg.
The Cosmo City development was thus apportioned according to house values comprising a split between 4 992 fully subsidised houses, 2 959 finance/credit linked units (ranging from R180 000 to R280 000) and 3 337 bonded houses in the R380 000 to R800 000 price range.

BREAKING NEW GROUND

As the first development of its kind and scale in South Africa, Cosmo City has become a point of reference for the type of public housing envisioned under the government’s Breaking New Ground programme, where the emphasis has evolved to assert the idea of subsidised homes as assets, with title deeds assisting in the development of the secondary market.

The Department of Housing’s 1997 Urban Development Framework sets out government’s mandate to develop environmentally sustainable urban settlements in conjunction with the regulatory and environmental policy that would enable the most efficient trade-off between building affordable and quality housing on the one hand, and using renewable and non-renewable resources to balance consumption needs.

SUSTAINABLE STRATEGIES

In line with the broader vision contained in South Africa’s National Sustainable Development Strategy, the Urban Development Framework looks to the sustainable use of resources and the protection of ecologically sensitive areas as a focal point for future urban development.

Integral to environmental planning is the creation of green belts, open spaces and parks – features previously confined to affluent suburbs. Prior to construction on Cosmo City, an Environmental Management Plan set out a list of criteria for the fulfilment by the developers and professional teams on the project.

These included the development of:

i) an Ecological Management Plan for the conservation areas, ii) Environmental Management Plans for construction and operational activities on site,
iii) an Environmental Impact Assessment Report (focusing on heritage, geology, soil, hydrology and storm water attenuation), and iv) a Biodiversity Report.

**COSMO CITY ENVIRONMENT MANAGEMENT**

Once these had been completed and construction started, all building activities on the site had to be strictly monitored by a full-time environmental control officer, prescribed in the Environmental Management Plan and approved by the Department of Agriculture, Culture and the Environment (GDACE).

According to Kannenberg, nearly 21 000 protected and medicinal plants (ahead of the construction work) were transplanted to the Suikerbosch Rand Nature Reserve, and the indigenous vegetation on the Cosmo City site was preserved in a 300-hectare conservation park, protected by a 42 kilometre palisade fence.

Whilst it was inevitable that in the development process, large tracts of natural vegetation would be lost, compensation was made for this by planting trees and shrubs throughout.

“The fact that the terrain was sandy was a challenge because of erosion. However, the grassing of municipal parks by the City Council and the establishment of gardens throughout Cosmo City reduced the impact of this dramatically,” says Kannenberg.

Basil Read Developments established a pilot nursery at Cosmo City and trained staff to propagate trees and shrubs as part of its Green Projects programme. Using the latest innovative technology, the nursery conducts ongoing research on, for example, the use of micro-organisms and earthworm farming to help create and maintain sustainable ecosystems.

There is also continuous cross-linking between these kind of private programmes and municipal schemes aimed at making Cosmo City an environmentally cohesive development.

For example, the City of Johannesburg, in its Climate Proofing of Urban Communities project, installed 700 low-pressure solar water heater (SWH) units, distributed compact fluorescent lamps and fitted insulated Isoboard ceilings in all the subsidised houses.

This follows on from the first phase of installation of 170 SWHs in 2007 as part of the Department of Energy’s target for the provision of one million SWH units throughout the country within five years. The low-cost units have also all been fitted with prepaid water and electricity meters.

**STORM WATER MANAGEMENT**

One of the most important aspects of the development, and critical to the first stages of the Environmental Impact Assessment, was the storm water management.

This was designed by WorleyParsons and its joint venture partners using Civil Designer’s storm water module application – with its multiple pipe layer functionality for the capture of pipe layer data according to dimension and material.

Kannenberg says: “The increased storm water runoff is attenuated by a series of carefully designed and placed attenuation dams, thus mitigating the effect thereof on the downstream properties along the banks of the Zandspruit.”

Using the Civil Designer software helped WorleyParsons facilitate the shared design of Cosmo City’s civil infrastructure, which the other joint venture partners also used. Cosmo City has nearly 130 km of internal streets and similar lengths of water pipes.

The City of Johannesburg manages the essential services and maintenance of park and environmental areas. In its entirety, Cosmo City is the kind of development envisioned in the City’s Spatial Form and Urban Management Sector Plan that aims to “create a physical environment that meets the current needs of communities, but also protects the interests of future generations.”

As a point of reference for similar development models, the significant elements of Cosmo City’s success have been the strength of the public-private partnership combined with the buy-in of the communities, whose ownership of the development, through the Cosmo City Residents Association, has created a sense of pride and sustainability.

Talking of this key project in his 33-year career, Kannenberg says: “It was a unique development at the time of its conception, and it has since been replicated as a model for integrated, mixed-use and sustainable housing. Knowing this makes me proud to have been part of it from the beginning.”

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IN BRIEF

ZEEOGAT WWTW UPGRADE

THE MURRAY & ROBERTS CONSTRUCTION POWER Joint Venture is making excellent headway on a R190-million contract to execute Stage 1 of the upgrade and expansion of the Zeekoegat Waste Water Treatment Works (WWTW) near Pretoria, on the Pienaars River.

The contract was awarded by the City of Tshwane in October 2010 and calls for the construction of a new 40 ML/day BNRAS (Biological Nutrient Removal Activated Sludge) module to boost the existing capacity of the WWTW. Completion is scheduled for early 2013.

Detailed design and supervision of the extensions was awarded to the BAKV3 joint venture, comprising BIGEN Africa Services and KV3 Engineers.

Anton Botha, contracts director at Concor, a subsidiary of Murray & Roberts, says this contract has taken a unique turn in that, in addition to the civil work, the M&A Construction Power JV has been given responsibility for project managing the mechanical, electrical and instrumentation components of the work, including dry and wet testing, commissioning and final handover of the plant to the client. Lektratek Water Technology is the mechanical partner and EDSE Projects, the electrical partner on this project.

“This ‘single source’ approach is unique in the civil industry,” Botha says. “We have established excellent relationships with the mechanical and electrical contractors and we are proving that we can successfully coordinate the implementation of these disciplines in a project of this nature. Based on this track record, we are already tendering for other similar projects offering the same ‘package deal’ approach.”

The JV will supply 15 000 m³ of concrete, 47 000 m² of formwork and 1 600 tons of reinforcement for Stage 1 of the Zeekoegat WWTW upgrade and expansion.

The modifications to the existing works include supply and installation of a third 8 mm screen at the existing screenings chamber, construction of three additional vortex degritters, and a new division box to split the flow between the existing and the new module, as well as construction of a new finescreen structure.

The contract includes three new conventional 25 m diameter primary settling tanks, equipped with rotating bridges and scrapers. Primary sludge will be drawn off to a new primary sludge pump station that will transfer it to a sludge handling facility that will be constructed in Stage 2.

A new 10 000 m³ balancing tank will allow a six-hour retention period and will be equipped with 16 vertical shaft stirrers to prevent the organic matter from settling.

Two identical new biological reactors, each capable of handling 20 ML/d, are being constructed and configured to incorporate several process configurations. Diffused aeration has been chosen as the method of aeration, based on its energy efficiency and the fact that the existing plant already operates on diffused air. The unaerated zones will be equipped with 40 vertical shaft stirrers, and 20 axial flow pumps will be installed for internal recycling purposes.

Included in Stage 1 are four new 35 m diameter secondary settling tanks, equipped with rotating bridges and scrapers. Return activated sludge (RAS) will be withdrawn and pumped to the biological reactors.

A new chlorination contact tank has been sized to handle the eventual total flow of 85 ML/day. The tank has been split into two separate units to allow for disinfection to take place when one unit is taken out of operation for cleaning and maintenance.

An additional estimated electrical load of 4 MVA will be required for the extensions to the plant. The bulk power on site will be distributed to various 11 000/400 V substations and mini-substations.

INFO

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The Murray & Roberts Construction Power JV is responsible for the mechanical, electrical and instrumentation components of the upgrading work at the Zeekoegat WWTW, where some 15 000 cubic metres of concrete have been used for modifications and new structures.
INNOVATIVE SOLUTION FOR THE GAMTOOS BODKER PIPELINE PROJECT

THE DEPARTMENT OF WATER AFFAIRS (DWA) undertook a major rehabilitation programme of the Gamtoos canal system in the Eastern Cape. The challenging repair of the Bodker Tunnel was achieved using Agilia™ self-compacting concrete from Lafarge Readymix, with minimum disruption to the supply of irrigation water.

The Gamtoos River valley with its fertile alluvial soil is a major production area for export citrus fruit, together with vegetables and a wide range of other crops for the local market. The majority of the crops are grown under irrigation, and the canal system, which was constructed in the 1960s by the DWA, is the lifeline for the farmers. A portion of the water supply is also transferred to the Loerie Dam for distribution, after treatment, to the Nelson Mandela Bay Municipality. Traversing majestic but difficult mountainous countryside, the open canals, tunnels and siphons were in need of rehabilitation.

The original Bodker Tunnel comprised 140 m of concrete tunnel located in difficult terrain, with difficult access.

The rehabilitation works, carried out by WK Construction for the DWA, involved lining the tunnel with a 1,9 m diameter steel pipe and grouting the annulus with concrete. The conveyance and...
compaction of the concrete was a major challenge, particularly as all works had to be carried out during two shutdown periods of only two weeks each. A standard self-compacting concrete (SCC) is usually considered to have a 120 minute handling lifetime and requires offloading from a truck-mixer in a single continuous pour. Agilia™ SCC was supplied from the Lafarge Readymix plant in Uitenhage and transported for two hours to the top of the adjacent Bodker Siphon, where it was discharged into a chute and conveyed by pipeline to a hopper at the bottom of the hill some 90 m below. From the hopper, the Agilia™ was pumped 140 m through the original concrete tunnel, finally discharging into the annulus between the new steel liner and the original concrete tunnel.

“The process involved subjecting the Agilia™ to handling practices that are generally not even possible with conventional concrete,” comments Lafarge Readymix’s Product Manager, Brent Paterson. “The product’s performance exceeded the client’s expectations, while saving labour costs and the need for extra pumping lines. In addition, Agilia™ was achieving 28-day strengths of 55 to 60 MPa.”

Careful planning and excellent coordination was also required between the Readymix delivery team, the concrete pump and hopper teams, and the grouting team at the pipe shutter inside the concrete tunnel to ensure a smooth operation with no blockages.

The time spent on the repair was critical to avoid dire consequences for some of the farmers – the total shutdown period was restricted to two periods of a fortnight spaced approximately four weeks apart. “Agilia™ played a major role in completing the key concreting phase in only ten days,” says WK Construction’s Contract Manager, Richard Pringle. “The way in which Agilia™ filled the annular void from the base up with negligible segregation after being dropped 90 metres and pumped over 140 metres was extremely impressive.” Endorsing Pringle’s comment, Site Manager Martin Deyzel said that he had worked fifteen years for WK Construction and Agilia™ was an eye-opener and a winner. He also complimented Lafarge on their excellent service with on-time deliveries in challenging terrain, backed every day with full technical support.

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STELLENBOSCH UNIVERSITY WATER RESEARCHERS COMBINE FORCES

THE STELLENBOSCH UNIVERSITY WATER INSTITUTE, an initiative that aims to strengthen the already sterling work being done by its academics in the field of water research, was launched on World Water Day.

The event, which was attended by Mrs Naledi Pandor, Minister of Science and Technology, was preceded by a well-attended public seminar. In her keynote address Minister Pandor said that it is vital for policy-makers to follow a model such as that of the Stellenbosch University Water Institute (SUWI), which not only ensures that new knowledge is created, but also that it is applied to address current water challenges. She also urged for stronger links between scientists and policy-makers, and asked researchers involved in the Institute for their commitment to multi-disciplinary research, not only with partners elsewhere in South Africa, but also with those at institutions throughout Africa, in an effort to ensure necessary skills development within the water sector.

Glasses of water were raised to the success of the Stellenbosch University Water Institute (SUWI) by US Rector and Vice-Chancellor, Prof Russel Botman (left), the Minister of Science and Technology, Ms Naledi Pandor, and the chairman of the SUWI advisory board, Prof Eugene Cloete.

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At the event Prof Eugene Cloete, dean of the SU Faculty of Science and chair of the SUWI advisory board, said: “Our University has over the years built up excellent capacity within the field of water research, in various departments and various faculties. By uniting our researchers in such a way I believe we have created a national asset that actively contributes towards solving South Africa and the continent’s water related challenges. South Africa needs a blue revolution – one in which national assets such as the SUWI can drive the development of technology, innovation and further research to ensure clean, affordable and quality water provision and sanitation.”

Microbiologists, polymer scientists, soil scientists, geologists, invasion biologists, engineers, zoologists, food scientists, biochemists, agricultural economists and a philosopher count among the affiliated researchers who work on topics such as the ethics of freshwater management, ownership of water, the safety of agricultural produce, bio-fouling and bio-corrosion control, community health, financial-economic planning of water use, endocrine disruptors, hydrodynamics, water engineering, catchment and resource management, invasion biology, the geochemical evolution of water and waste water, water governance and management.

“The only way to stem predictions that South Africa will run out of water, is to ensure that we have the necessary technology in place to recycle and re-use our water, that we keep our drinking water clean and that we ensure that we sustainably harvest as much water as possible,” says Prof Cloete.

Other speakers were Prof Hamanth Kasan, general manager of Rand Water’s scientific services division, Dr Rivka Kfir, CEO of the South African Water Research Commission, and Prof Anthony Turton, an environmental advisor and vice-president of the International Water Resource Association (IWRA).

From GIS records, it was identified that approximately 2,000 km of 160 mm un-dipped AC pipe needed replacing. Through a tender process based on the New Engineering Contract (NEC3), Aurecon was appointed as programme manager, together with four design consultants and four large contractors, to implement the AC pipe replacement project, which began in July 2007.

To ensure delivery excellence on such a large project, it was necessary to divide eThekwini into four geographic areas with a large contractor, design consultant and four sub-contractors allocated to each area. Based on the burst records, reservoir zones within each area were prioritised for pipe replacement. A detailed proving approach was followed to ensure that the replacement pipes would meet the demands of the system.

SECURING ENHANCED WATER INFRASTRUCTURE FOR ETHEKWINI’S CITIZENS

COMPRISING THE CITY OF DURBAN and 64 incorporated local authorities covering an area of 2,300 km², the area of eThekwini Unicity experienced up to 150 water main bursts daily, and frequent leaks. A prime cause of these problems was the failure of un-dipped asbestos cement (AC) water pipes used to distribute the area’s water. Because eThekwini’s water is ‘soft’ (i.e. lacking in calcium and magnesium), it reacted chemically with the lining of the 25–50 year old AC pipes, causing softening and deformation which ultimately led to leaks and bursts. The cost of these bursts was estimated at R584 million per annum.

From GIS records, it was identified that approximately 2,000 km of 160 mm un-dipped AC pipe needed replacing. Through a tender process based on the New Engineering Contract (NEC3), Aurecon was...
exercise was then carried out to verify the existing pipe position and material composition. All un-dipped AC secondary pipes found were identified for replacement and the necessary works information prepared to enable the contractor to formulate an accurate target cost and activity schedule. Following approval by Aurecon, in its capacity as programme manager, an access date was given so that work could commence. A key deliverable of the project was to replace 80 km of pipe per month. Because the bulk of the work was carried out using labour-intensive methods, this deliverable was challenging. It was eventually achieved, however, and in some months exceeded. At the end of 30 months, approximately 1 600 km of pipe had been replaced at an average rate of 53 km/month.

From the beginning, the project was community focused, with clearly defined social deliverables. These included a mentorship programme involving 16 emerging sub-contractors and the recruitment of local labour in areas where the project was to be implemented. In addition, local businesses provided project resources wherever possible.

An incredible 45 000 jobs were created over the project’s three-year lifespan, with the 16 sub-contractors who participated in the mentorship programme all achieving at least a two-notch upgrade using the Construction Industry Development Board’s rating system.

A professional communications programme was implemented on the project with the aim of assisting the municipality to achieve community buy-in by providing accurate information to consumers. This included an eye-catching logo used on all project communication tools, as well as a website which was frequently updated with new material.

The replacement of the old AC pipes with new mPVC pipes will result in an estimated saving of R248 million annually, with obvious benefits to both the economy and the environment.

On completion, all of the pipes laid were accurately captured by a Global Positioning System to enable the eThekwini GIS database to record the position and length of the municipality’s new asset. To date, no leaks or bursts have been recorded on the 1 600 km of pipes laid during the project’s three-year lifespan. The project has received three awards, including the prestigious Kamoso award for Best Construction Project in South Africa.
Multotec’s state-of-the-art fully automatic filter press, based on the successful Seprotech Rapid Filter (SRF) press, eliminates the risk of any contamination in this application. This exciting new product has been developed using patented technology, with components sourced internationally to ensure long life and spares availability. The new filter press has been 100% locally manufactured at Multotec’s ISO 9001 accredited facility.

The hydraulic power pack has been replaced with a water pressure system which, while achieving the same clamping force, ensures optimum sealing of the plate pack while dramatically reducing noise pollution. The filter cloths have been further developed to ensure longer life, in turn achieving lower consumable consumption. Components have been designed to ensure safe operation, while finite element analysis has been applied to substantiate the integrity of the machine. The filter press is characterised by its energy efficient electric motors.

Multotec’s new water filter press is ideal for use in a water reclamation plant where lime is used to neutralise AMD and the resulting gypsum slurry needs to be filtered out. The clean filtrate water is fed back into the plant for further processing and the filter cake produced can be sent for further processing to ultimately enable it to be recycled as a valuable product.

The new filter press can also be used in other liquid/solid separation applications, including copper concentrate, platinum concentrate and coal fines. Capacity is dependent on the application requirements.

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1. The cloth wash system on the Seprotech Rapid Filter Press features spray bars permanently installed at the top of every plate
2. The Seprotech Rapid Filter Press plate pack is clamped in position using a water pressure system
3. Diagram depicting how the Seprotech Rapid Filter Press plate pack opens in a concertina-type movement
ATLAS COPCO EXTENDS ITS ENERGY EFFICIENT BLOWER PORTFOLIO

ATLAS COPCO’S OIL-FREE AIR DIVISION recently introduced the ZB 5-120 VSD. This innovative 100% oil-free range of centrifugal air blowers with Variable Speed Drive (VSD) is the manufacturer’s latest addition. At the heart of the new ZB range is a state-of-the-art air foil bearing technology that ensures high energy efficiency.

The ZB range delivers 100% oil-free air according to ISO standard 8573-1 and eliminates any risk of oil-contamination in the aeration system. The distinctive air foil bearings allow friction-free flotation of the high-speed rotor. Coupled with the leading VSD technology, the highest air volume at the lowest energy consumption is assured.

Typically, the aeration system in a biological waste water treatment plant accounts for up to 70% of the total energy usage. To significantly lower operational costs in these continuously operating plants, the new ZB range incorporates the latest technologies in the most efficient and durable design.

Chris Lybaert, President of Atlas Copco’s Oil-free Air Division, says: “Not only does this range address the specific needs for waste water treatment plants, it also proves our determination to innovate and develop sustainable products that truly add value for our customers.”

INFO
Wayne Jacobs
Business Line Manager
011 821 9120
wayne.jacobs@za.atlascopco.com

1 and 2 Atlas Copco’s ZB range delivers 100% oil-free air and its distinctive air foil bearings (photo 2) allow friction-free flotation of the high-speed rotor

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DAWIE BOTHA, who retired from SAICE a year ago after having served as Executive Director for nineteen years, received the 2010/11 NSTF-BHP Billiton Award in the category Management and related science, engineering and technology activities over the last 5-10 years, at a gala event in Johannesburg on Thursday 26 May.

Dawie received the NSTF (National Science and Technology Forum) award in recognition of his dedication and professionalism in promoting and supporting capacity building through the civil engineering profession, both locally and internationally. Throughout his years of service as Executive Director, Dawie made use of every opportunity to promote civil engineering as an essential profession necessary for the development, operation and maintenance of the built environment infrastructure. He did this by liaising with government representatives (including a number of ministers), by engaging with the media, through presentations and articles, and by networking with sister- and associated organisations locally and internationally.

Dawie was indeed instrumental in putting civil engineering on the South African map and raising SAICE’s stature internationally. He was responsible for establishing the Africa Engineers Forum in 1995, which resulted in cooperation among the signatories regarding capacity building in Africa. He is a member of the Capacity Building Committee of the World Federation of Engineering Organisations (WFEO) and is sought after internationally by engineering institutions on matters regarding capacity building in the civil engineering industry. Together with local and international colleagues he co-authored the *World Federation of Engineering Capacity Building Guideline 2010*, which was launched in October 2010 at the WFEO Executive Meeting in Buenos Aires.

By receiving this award, Dawie follows in the footsteps of Allyson Lawless and Bob Pullen, both past presidents of SAICE, and both of whom received NSTF awards in 2008 and 2009 respectively. Together with Allyson and Bob, Dawie now finds himself in the top echelon of achievers who have been recognised and awarded in the fields of science, engineering, technology and innovation in South Africa.

The award was handed to Dawie by the Minister of Science and Technology, Naledi Pandor. In her inspiring keynote address, Minister Pandor, who is also the patron of the NSTF awards, reassured the science, engineering, technology fraternity of her department’s continued support, saying to them that “the good times for researchers are here”.

Minister Pandor continued by saying, “After all is said and done, we should always remember that our science mission is to create wealth, thereby creating jobs and eradicating poverty.”

In his acceptance speech, Dawie quoted former President Thabo Mbeki, who had said, while addressing SAICE members and guests at the Institution’s centenary banquet in 2003, that civil engineers are the Leonardo da Vinci’s of the 21st century, but that they should remember who they are serving – “the people with the broken finger nails, those with very little to celebrate”.

We extend our warmest congratulations to Dawie, who, we are sure, will dutifully respond to Minister Pandor’s appeal to all recipients of 2010/11 NSTF awards to “take up the call when your country needs you to represent it at continental and global events.”

---

> Dawie Botha, middle, with Naledi Pandor, Minister of Science and Technology, left, and Dr Thulani Dlamini from the CSIR
TO ALL CORPORATE MEMBERS

NOMINATIONS FOR ELECTION OF COUNCIL FOR 2012

THE SOUTH AFRICAN INSTITUTION OF CIVIL ENGINEERING – Nomination for election of Members of Council for the year 2012 in terms of Clause 3.1 of the By-Laws

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 shown 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: 29 July 2011. 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 2011. 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.

In accordance with Clause 3.3 of the Constitution, the Council has elected Office Bearers for the Institution for 2012 as follows:

<table>
<thead>
<tr>
<th>Office</th>
<th>Name</th>
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<tbody>
<tr>
<td>President</td>
<td>Dr M van Veelen</td>
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<tr>
<td>President-Elect</td>
<td>Mr P Kleynhans</td>
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<td>Vice-President</td>
<td>Mr T McKune</td>
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<td>Mr S Naicker</td>
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<td>Mr S Mkhacane</td>
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<td>Vice-President</td>
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In terms of Clause 3.3.4 of the Constitution, the following are ipso facto members of the Council for the year 2012:

<table>
<thead>
<tr>
<th>Office</th>
<th>Name</th>
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<tr>
<td>The immediate Past President</td>
<td>Mr SN Makhetha</td>
</tr>
<tr>
<td>The two most recent Past Presidents</td>
<td>Mr AM Naidu</td>
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<td>Prof EP Kearsley</td>
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M Pillay
Chief Executive Officer
April 2011

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## NOMINATION FORM 2012

### 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 29 July 2011

Fax: 011 805 5971 | E-Mail: mscheepers@saice.org.za | Postal address: Private Bag X200, Halfway House, 1685
Jan Abraham de Wet

JAN DE WET, for many years a prominent member of the consulting engineering fraternity in Pretoria, and Director and past Chairman of Ninham Shand, passed away on 9 January 2011 at the age of 84, after a short illness.

Jan was born in 1926 on a farm near Hopetown, the third of eight children (five sons and three daughters) and retained links with that area throughout his life.

Jan, proud of his heritage and home language (he was equally proficient in English) was a dedicated family man and his farming background provided a platform to develop his keen interest in nature.

He obtained his BSc in civil engineering at Stellenbosch University, where he was one of the earlier students to study for his degree in Afrikaans at what was then a new engineering faculty.

He later worked for the Stellenbosch Municipality before being recruited by Ninham Shand in 1956.

In 1963 he was transferred to Pretoria, where he opened a Ninham Shand office in the Merino Buildings in Pretorius Street. Jan soon established a good reputation, and became an influential presence in the consulting community of the region. Work for the company increased, leading to the need for larger premises. After various moves they constructed their own building at the Waterkloof Forum.

Jan was active in the South African Association of Consulting Engineers (as it was then known), becoming chairman of the Pretoria branch in 1972, and National President in 1984/85. This involved a number of visits to other countries associated with FIDIC (the international federation of consulting engineers). During his term as President of the Association the profession was doing much soul-searching regarding the ethics of marketing, and Jan provided some wise guidelines which were adopted at the time.

Jan became involved in many projects awarded to Ninham Shand, including a share of the very large Orange River Scheme developed by the Department of Water Affairs. The Pretoria office of Ninham Shand was also responsible for a significant part of the advance infrastructure for the Lesotho Highlands Water Project. Jan played a role in various aspects of the project, and served as Chairman of the Lesotho Highlands Tunnel Partnership and Highlands Delivery Tunnel Consultants for a number of years, up to and after his retirement from full-time employment.

Jan became Chairman of Ninham Shand in 1986, a position which he filled until his retirement in 1992.

He was a keen golfer and member of the Pretoria Country Club, and became chairman of the Old Maties Golf Club. Some years before his retirement, he bought a farm in the Bushveld where he raised cattle, and for the rest of his life he loved to spend time there with various family members, as well as with former colleagues who had become close friends. He had an extensive knowledge of the veld, with particular interest in soils, trees, grasses and birds. Jan was always hard-working and an early riser, and loved to walk in the early mornings as the bush awoke with the rising sun. He was a keen hunter and crack shot, and permitted his friends to also hunt while accompanying him on visits to the farm. There was always talk about fresh liver to be cooked on the fire for breakfast, but this seldom happened. Jan maintained strict control over what he considered as fair hunting, which took place on foot through the thick bush.

Above all, Jan was a man of integrity. He was forthright and strong, did not mince his words, but was always ready to listen to the other point of view. He was widely read and had a delightfully keen sense of humour. His mentorship of many of his staff prepared them well for their work and lives as competent civil engineers.

Jan will be sorely missed by his wife Anne, his children, and many other family members and friends.

Tony Mills
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<td>Business Finances for Built Environment Professionals SAICEfin08/00405/11</td>
<td>Wolf Weideman</td>
<td>Dawn Hermanus <a href="mailto:dawn@saice.org.za">dawn@saice.org.za</a></td>
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