LINING THE GAUTRAIN TUNNEL
ENVIRONMENTAL ENGINEERING
Blue Flag Debate
Mining Waste Management
WESTERN CAPE: Berg Water Project Supplement Scheme
SAICE IN PARLIAMENT
The Gautrain TBM — colossal moving factory boring and lining in one operation 46

VIEWPOINT
Engineering the soft issues in South Africa 3

ENVIRONMENTAL
Coming down to earth 6
True Blue 8
An engineering response to the sea water quality issues in Durban 10
Imesa establishes Saldanha Bay Forum 12
Legal obligations regarding the lifecycle of a mine tailings storage facility 15
South African mine residue disposal practices in a global context 19
Addressing the social impact of mining activities on communities for sustainability 22
Some rehabilitation issues on Witwatersrand gold tailings dams 25
Selecting the right tailings disposal solution — a case study 31
Increasing emphasis on environmental protection at all stages of engineering projects 36
Oostenberg integrated waste management facility 39
De Hoop Dam brings hope 41

WESTERN CAPE
Berg River Dam rushed to completion 49
The Berg Water Project supplement scheme 50

OTHER PROJECTS
CRBs facilitate building on steep slopes 57
Massive retaining wall project at FNB-Wesbank development 62

IN BRIEF 64
■ Masdar Initiative in Abu Dhabi ■ Hot Dip Galvanizing Industry acknowledged at Africa Energy Awards 2008
■ World Rivers Day set for 28 September ■ New facet to SA’s fast growing recycling industry ■ New waterproofer to the aid of seal pups ■ The Simbithi ECO-Estate Project ■ SA builders to meet amidst severe challenges ■ Demand for C&C training soars in midst of building boom ■ Arcus Gibb acquires African Consulting Engineers

PEOPLE 73
■ Top management changes at Vela VKE ■ Cecil Rose appointed to CIDB ■ Spending time in Nigeria

SAICE AND PROFESSIONAL NEWS
NSTF Awards’ tenth birthday — and a present for SAICE 75
SAICE at work in Parliament 76
We welcome a new editor 76
News snippets on Loading Code 77
BKS-SAICE ‘Take a girl-child on site’ 78
SAICE student chapter UCT 78
CPUT student receives SAICE award 78
SAICE Smart Awards 2008 79
Diarise this! 80
engineering

the soft issues in South Africa

South Africa stands once more at a fork in the road. On the one hand we see lurking the shadows of infrastructural decay—power supply, sewerage, water supply and other infrastructure failures are upon us, or imminent, and experienced engineers are leaving the country. On the other hand we strive for the vision of the Rainbow Nation—a united country that has turned its back on racial hatred and grasped prosperity for all its people in a never before seen peaceful regime change that captured the hearts and minds of the entire globe. But the dream has faded and acrimonious debate, blackouts and violence seem to be winning after all.

What has this to do with engineering? In 1989 I left the formal practice of engineering to turn my attention to ‘bringing the disciplines of engineering to the information technology industry’. A dream that I, too, have found elusive and far more costly to attain than I ever visualised. In the process I have come to understand that the so-called ‘soft’ issues—psychology and the like—which I then considered to be irrelevant are, in fact, harder than concrete and much more challenging to overcome.

A human being who has decided NOT to change is probably the most difficult system in existence to change. And a human being who does not understand that change is required, nor what the change is, looks very similar to one who has decided not to change.

I have come to understand that the art and science of engineering—the ability to define a problem, devise a solution, and design and execute that solution so that it works reliably and dependably—is perhaps the most critical skill required of this generation. The world we live in is like no other in recorded history. There are more people, companies are larger and the rate of change of society is accelerating in ways we are not well equipped to adapt to. The application of systematic engineering skills in more depth and breadth to understand and manage change are therefore vital.

For this reason engineers are also vital to the future wellbeing of South Africa and I appeal to all engineers to step outside the box and seek to understand what it is that we as engineers know that is vital to help take our wonderful country to the next level.

In the course of my journey I have come to understand that ‘engineers do not design bridges to stand up, they design them not to fall down’.

Please pause a minute and reflect. When you were at university, did they teach you to ‘visualise’ successful engineering designs? No, they taught you about factors of safety and probability of failure, and you spent your time at university understanding what was required to prevent the failure of engineered solutions with the certainty that a system that does not fail has succeeded.

What has this to do with the future of this nation? Much in every way—we need to talk about the things that are not working, understand why they are not working and develop solutions that will generate sustainable wealth and economic well-being. When I speak about a low-road scenario I am NOT being negative or pessimistic. I am making an engineering diagnosis which, once it has been made, permits me to analyse what is required to prevent failure. Until we admit that failure is inevitable in the absence of informed, focused, goal-directed constructive action, and while we refuse to talk about failure on the grounds that such discussion is unpatriotic or even racist, then we are committing ourselves to failure as surely as if we designed a bridge without eliminating all possible causes of failure.

As an engineer you know that it is possible to visualise anything. I am certain that you have lain awake at night and visualised a solution to a problem only to find that when you came to commit it to paper and turn it into an actionable design something did not fit and you had to go “back to the drawing board” (or CAD workstation).

So it is with social change. We can visualise a nation united and prospering, where poverty no longer exists and racial demographics are a hazy memory. Yet we continue to experience that the vision is proving more difficult to realize than we want. Frustration is rising and some people are saying that racial tension in South Africa today is the worst it has ever been. Indications are that a large number of skilled and experienced people with material net worth have left the country.

What is required to prevent failure and how do engineers play a role in this? The following are some factors that are vital to achieving success.

As engineers we understand that systems that are not regularly maintained will experience exponential decay. If you

Civil Engineering | August 2008
do not change the oil in your car at the scheduled intervals, wear will accelerate progressively until the engine ceases to function reliably. This applies to all engineering systems including core infrastructure. From evident deterioration of this infrastructure it seems apparent that this principle is NOT widely understood. In fact, at some level one must conclude that current apparent economic prosperity results at least in part from serious discounting of the investment required for maintaining infrastructure sustainably. The bubble may be closer to bursting than we want to admit.

An economy that will generate wealth for all South Africans must be based on a proven economic model, which in turn requires reliable and sustainable core infrastructure. This requires engineers and an engineering approach. Change in direction of physical projectiles such as cars, planes and ships follows a curved trajectory tangential to the direction of travel at the moment change is initiated. Attempts to change direction beyond the constraints of the laws of physics result in loss of control, or failure to change as required. Evidence the example of the Titanic and the ice berg. The change of human systems follows a comparable trajectory and is subject to comparable constraints albeit psychological and not physical. These psychological constraints are every bit as solid as those in the physical realm, yet are little understood and seldom taken into account in planning change.

As much as we may desire to see instantaneous change in our beloved country, there is a stalling point beyond which the gains of recent years may be rapidly lost. It seems that we may well be rapidly approaching this point and I suspect that you will find that your experience is similar.

This being so I conclude that we absorb critical tacit knowledge and experience in the first five years of our lives that is NOT taught in schools and is not even recognised as being necessary by the education system. If we ignore this reality we condemn those born in ‘disadvantaged’ settings to a massive hurdle with regard to becoming engineers even before they have been further prejudiced by inadequate schooling in maths and science, let alone in the semantic use of English, and other impediments. Effective supplementary education in these areas of knowledge and experience are vital to bridging the gap necessary to achieve a demographically representative population of engineers.

To further compound this phenomenon the acquisition of composite knowledge and experience, also known as wisdom, necessary to successfully design and build complex engineering systems, probably takes most of us to at least the age of forty, if not longer.

When these constraints are combined with the points raised above it becomes apparent that the time required to produce a demographically representative and politically acceptable engineering population is a minimum of about sixty years. Insistence on doing this in less time will produce the stall effect discussed above as evidenced by the exodus of mature and experienced engineers, which is effectively achieving demographic balance by reducing the size of the pie when, in reality, what is required is that we grow the pie (the economy) as fast as possible.

In closing I suggest for your consideration that a mountain looks different depending on the route that you follow to reach it. Thus the Drakensberg looks very different to someone driving from Johannesburg to Durban contrasted with the view one gets driving from Durban to Johannesburg.

And so the mountain of the future South Africa looks very different when viewed from the perspective of a person raised in privilege with quality education versus the view of a person raised in poverty with access to only the most basic education. These views are real and different and there are many other views of the same mountain. Engineers and marketers, for example, see the mountain very differently, and so it goes.

So we find ourselves gathered in the foothills of the mountain of the future South Africa, dimly seeing diverse contrasting views and shouting angrily at one another that ‘they’ are going the wrong way or climbing the wrong mountain and that they should all come around to our way of thinking.

It is critical that we find a way of talking about our different views, seeking to understand those views and agreeing on a way up the mountain that experience indicates has a reasonable prospect of working, and then sticking to that path, even if it is an untravelled route.

It is time to admit our differences and see wealth as something that is NOT endowed or bestowed by fiat, but as something that is earned by the earnest application of our life knowledge and experience, using technology as an enabler to gear our ability.

In such an economy engineering is perhaps the most vital skill.

I urge all engineers to step up to the challenge of bringing their problem-solving ability to bear on the mountain of national prosperity for all. SAICE and the engineering profession generally have a critical role to play. Let us facilitate constructive dialogue in those sectors where we have real influence.

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THIS YEAR, the International Year of Planet Earth (IYPE), offers an ideal opportunity for civil engineering professionals to position themselves in terms of green engineering, and to go public with these principles.

The IYPE was proclaimed by the United Nations General Assembly to raise worldwide awareness of the vast potential of earth sciences for improving the quality of life and safeguarding the planet. More effective use of such knowledge would not only save lives and protect property in times of natural disasters, but would also enable us to satisfy, in a sustainable manner, the increasing needs of an ever growing human population for the earth’s limited resources.

Fast-forward to the contribution from the civil engineering profession.

By the very nature of their work and outlook, most civil engineering professionals have over many years aligned themselves with ‘green’ principles in the day to day execution of their tasks. They have often unassumingly been the custodians of their particular environment. But increasingly it is becoming necessary to drive green engineering more forcefully, i.e. away from esoteric, idyllic (and nowadays even fashionable) views of what our world should look like.

Practical and sustainable should be the key words. However green the planet, we still need infrastructure like roads, sewers, electricity, potable water. Buildings, after all, cannot reach towards the sky without foundations and structural skeletons.

How we achieve this is what defines and establishes green engineering. Often it entails a fresh way of looking at what has been taken for granted, or been done for years. We need to assess total cost not only to the pocket, but also to the environment. We need to re-use materials on a far larger scale than is presently the case. We need to preserve our invaluable resources, particularly water, for what they are inherently intended.

Rude human behaviour – think about it!

A crystal clear drop of water rains down onto a beautiful landscape somewhere in the Drakensberg. Many drops unite and a mountain stream picks up speed, taking with it precious soil from neglected or badly tended fields. The stream flows to a man-made dam from where the water is pumped up over the escarpment and, after the mud has settled, the pristine blue artificial lake called Sterkfontein delights the eye and preserves the precious commodity.

Note that ‘commodity’ is the unfortunate term.

When we become thirsty in Gauteng or end up in dire straits because of droughts, this water is released and again picks up silt and becomes polluted with fertilizer run-offs along the way, ending up in yet another dam. The water is now VAAL.

Then the water is pumped and purified and pumped-up elevated 300 metres to the city of gold, stored and ultimately reaches our homes where we use it and nonchalantly flush the toilet without giving it a further thought, as it is gone now.

But of course it is not gone! To exacerbate things we add some wonderful soap and detergents and hair conditioner in another bowl and pull the plug and away she goes, too.

And then we try to purify and make it bright and healthy again, although by now we cannot get the phosphates out any more, as it is far too expensive. We put it back into the Crocodile, and on its way to the Hartebeespoort Dam it catches rubbish from storm water systems.

Ultimately this pea-soup-commodity-wastes mixture is stopped in its tracks in a dam which engineers are trying to rescue. These rescue attempts include the introduction of floating islands of plants to reduce the phosphate loads in the dam.

To cut a long story short, our drop of water eventually lands up in Mozambique, fatigued and dirty and we then leave it to the sea to clean up.

Coming down to earth
Is this sustainable? Of course not! In Sweden I heard of closed-loop system toilets using oil for repeated flushing, since water-based wastes do not mix with oil and therefore the oil can be reused for further flushing. Hopefully plant oil is used so that the source is at least renewable!

Although we are trying hard in South Africa, we should perhaps write out a competition with a million rand prize to design a modern non-offensive socially-acceptable human-dignity-preserving bucket toilet system for South Africa.

Not in my back yard (NIMBY)
Unfortunately many environmentally friendly ideas are often killed by the public. NIMBY is indeed alive and well in many parts of South Africa!

In the UK some road verges are now left uncut and natural greenery is allowed to encroach, except where sight lines are needed for safety purposes. Likewise, along the Garden Route engineers and their environmentalist colleagues are recreating fynbos to form natural verges. But if we should try that along our free-ways in Johannesburg with all our lovely natural Highveld grasses, all would go up in smoke caused by thousands of burning cigarette butts flicked out of windows instead of into readily available ashtrays inside cars. Eventually, of course, these cigarette butts end up in the Hartebeespoort Dam.

Talking of traffic – why do we still refuse to accept LTOR (left turn on red), which could save us billions in fuel costs?

Why can a city like Minneapolis implement a sustainability policy by enforcing recycling and advising its citizens on how to manage the enormous volumes of autumn leaves, while we cannot even prevent illegal dumping in our suburbs?

Forward thinking and change in attitude
The time has come to be far more proactive with regard to green engineering.

We need to think further out of the box than we are already doing. We could, for example, promote the use of nuclear energy more vigorously and assist with demystifying the perceptions around this environmentally far friendlier source of energy.

Perhaps what we should ultimately be doing is changing our attitude by changing our altitude. Coming down to earth from our tower offices and communicating the green engineering principles that we as civil engineering professionals are striving for, or are already implementing, could go a long way towards educating the public, decision-makers and less likeminded colleagues.

And of course, consistently liaising with fellow built environment professionals, particularly architects, on the issue of green engineering could go a very long way towards creating an environmentally friendly living space for all of us. After all, as civil engineering practitioners we have a wealth of knowledge on sustainability, recycling, and energy-efficient materials and design to offer our built environment colleagues.
AROUND EASTER 2008 the media throughout the country was awash with reports of the loss of Blue Flag status on a number of Durban’s beaches. At the same time, significant column inches were devoted to a major sewage spill in the sea at Isipingo, south of Durban. As holiday-makers were heading to the coast to enjoy the holidays, this was exceptionally bad timing for these events to occur. Telephones kept on ringing in the tourism offices in KwaZulu-Natal as holiday-makers attempted to find out whether it was safe to swim in the sea in Durban.

The withdrawal of Blue Flag status on Durban’s beaches was largely as a result of the sea water not meeting the health requirements of Blue Flag. While the Blue Flag program recognises that there are times when water quality is compromised, e.g. at the start of the rainy season or when spillages occur from time to time, the permissible number of samples over the standards may be no more than 20%. Over the past three years on many of Durban’s beaches, the fortnightly tests undertaken by the eThekwini laboratory have shown deterioration in water quality and increasing levels of bacteria resulting in over 40% of samples exceeding the accepted standards. More recent results indicate that on many of Durban’s beaches the bacterial levels are 25 times that of the standards for South African bathing water quality set by the Department of Water Affairs & Forestry (DWAF).

Blue Flags have been flying over beaches throughout the world for more than 20 years and, according to the World Tourism Organization (WTO), Blue Flag is the most widely recognised eco-tourism label in the world. This is hardly surprising when one considers that there are Blue Flags flying over almost 3 500 sites in 38 countries. it is interesting to reflect that the program had its origins in France and the Mediterranean region in the 1980s when there were grave concerns about the impact of deteriorating water quality on tourism to the region.

BLUE FLAG A STANDARD OF EXCELLENCE

A Blue Flag flying over a beach is an indication that the beach and surrounds are managed according to world-class standards. For a beach to fly a Blue Flag, the beach must achieve standards of excellence in four main areas:

- water quality management
- environmental management
- safety and service
- environmental information for the public

These areas of compliance rely on infrastructure and services put in place by the engineering, and health and sanitation departments in municipalities.

It has been suggested that the Blue Flag program is a critical tool to measure success of water and effluent management in catchment areas. Coastal management is synonymous with catchment management. In South Africa, some of our best swimming beaches are in close proximity of estuaries and rivers that often bring poor water quality down to the coast. Whatever discharges into the sea is the final culmination of a journey through a catchment area. Should the infrastructure and services within a catchment area be compromised, the consequences will definitely be experienced at the end of the journey. Coastal municipalities have to implement comprehensive and effective catchment management programs in order to ensure good, healthy water quality at their beaches. Managing what comes out on the beaches requires interventions throughout what could be a large catchment area. This is probably the greatest challenge facing coastal municipalities when implementing the international Blue Flag program in South Africa.

ENGINEERING INTERVENTION ESSENTIAL

The reasons for the deteriorating water quality in the eThekwini area appear to be complex and will require significant and innovative engineering interventions. The events causing major sewage spills, the poorly performing sewage treatment facilities, and even the DWAF standards for effluent released from sewage treatment plants, all have to be investigated and better managed.
It is probably true to say that the average South African is not aware of the vitally important role engineering plays in ensuring that our cities are healthy and well managed. Water and sanitation issues lie at the heart of our quality of life. For Durban, interventions to improve sea water quality will be essential and will require immediate responses. Poor management of sewage infrastructure and storm water systems poses major health risks for both beach-goers and those living in close proximity of polluted rivers and ineffective sewage plants. The solutions will have to draw on a variety of sub-disciplines in the engineering field: environmental engineering, coastal engineering, construction engineering, and a multi-disciplinary approach is going to be necessary throughout the eThekwini catchment area to sort out the problems being manifested on the coast.

The city is obviously taking these issues seriously. City officials have already started implementing measures to better manage infrastructure in the city. Sumps are being put in place within the storm water system to redirect potentially compromised water away from the coast. This is good news.

It is interesting to note that in the majority of countries participation in the Blue flag program requires that there may not be any storm water outlets on Blue flag beaches! South Africa is exempt from this requirement.

eThekwini is not the first municipality to have Blue Flag status withdrawn owing to poor water quality. Margate beach on the KwaZulu-Natal south coast also lost its Blue Flag status, yet within twelve months the Hibiscus Coast municipality had implemented measures to improve sewage management and the beach once again received Blue Flag accreditation.

**WORLD-CLASS DESTINATIONS**

Tourism research indicates that our beaches are major draw cards for both domestic and foreign visitors. Durban’s economy is inherently linked to its beaches and rapid interventions will be required to improve water quality on its beaches, and in so doing, restore public confidence in the water quality along the beachfront.

Notwithstanding the challenges of meeting international standards on Durban’s beaches, more and more municipalities are subscribing to the Blue Flag program here in South Africa. In order to ensure compliance with standards, municipalities have to apply annually for the accreditation on their beaches. As South Africa prepares for the 2008–2009 Blue Flag season, twenty-six beaches from around the country have applied for the acclaimed Blue Flag status. In the current season there are eighteen beaches in the program.

One only has to see the volumes of traffic heading towards the coast at the time of the summer holidays to know that South Africans enjoy their holidays on the beach. For local visitors, holidays are synonymous with fun in the sun on the beach. With weather that allows all-year-round tourism and a booming tourism industry, we would like to see more and more Blue Flag beaches flying flags of excellence in future, assuring beach-goers that the water quality is being well managed and is healthy, that the beach and facilities are clean, and that the services in place will offer them a world-class beach.

Visit www.blueflag.org for more information.
An engineering response to the sea water quality issues in Durban

BEFORE DEALING WITH the engineering side of this issue, I believe it is important to first examine the science behind the decision taken by Blue Flag to withdraw status from certain of Durban’s beaches. The quality of sea water is impacted primarily by storm events which have the effect of washing pollution from the land into the sea. For a short period after these storm events, the quality of sea water can be impacted negatively in areas immediately adjacent to river or storm water drain discharge points. The impact of this pollution is short-lived because of the ability of sea water to destroy pathogens within a few days.

Given that the viruses and other pathogens which cause infection cannot easily and cost effectively be detected in the sea water, indicators such as E. coli, Enterococcus and other bacteria are used. These indicator bacteria are themselves not harmful – in fact the World Health Organisation describes them as “harmless organisms”. Provided that the indicators which are used have a life similar to that of the pathogens and exist in numbers that are in proportion to the level of pathogens in any sample, they can be used to determine the level of pollution of a water body.

A number of papers exist which show that, in tropical waters, Enterococci are not suitable for use as indicators of the existence of pathogens in water because the Enterococci are able to multiply on their own in the favourable environment which exists. Equally E. coli die off at a rate faster than the pathogens and may therefore under-report the degree to which a water body is polluted. The World Health Organisation, in one of its most recent publications, entitled “Monitoring Bathing Waters – a Practical Guide to the Design and Implementation of Monitoring Programmes”, states that “the lack of a strong relationship between faecal indicators and health outcomes in a number of epidemiological studies in warm tropical waters may, in part, relate to the inappropriate nature of E. coli or faecal streptococci as indices of water-borne pathogens in these recreational waters. In this context an alternative index group, sulphite-reducing clostridia or spores of Clostridium perfringens, have been proposed and are used in Hawaii.”

BLUE FLAG STANDARDS
Blue Flag in setting their standards require the E. coli count to be less than 100 colonies per 100 ml and the Enterococcus count to also be less than 100 colonies per 100 ml sample. From 2009, the Enterococcus level is to be reduced to 50 colonies per 100 ml sample.

Epidemiological studies have then been undertaken in the past to link the number of indicator colonies present in a specific volume of water, to the level of infection of bathers in contact with the water. At the time of most of these epidemiological studies, bacteria colonies were grown on media which gave far lower counts of colonies than the modern day media which are more sensitive and which give higher colony counts. Recent studies indicate that the bacteria colony counts detected using the more sensitive techniques of today, can be 50% to 100% higher than those detected in the past.

The Blue Flag literature does not prescribe a single method of testing for these indicator bacteria and until now has not responded to the statement from the World Health Organisation that Enterococci are not suitable for use as an indicator in tropical waters.

A CITY’S TASK
Having said that, it is clear that the aim of any city should be to minimise the levels and frequencies of pollution of its beaches to the absolute minimum.

Pollution of Durban’s beaches has a number of causes:
- river flows carrying sewage downstream from developments that are not yet connected to an acceptable sewage disposal system
- illegal interconnections of the sewer and storm water drains by residents on private property and abuse of the sewerage system
- the recent pumping of sand from the harbour itself onto our beaches
- pollution flowing down nine storm
water drains from the central city region and onto the central beaches, sewers that leak into rivers after damage by severe storm events, or vandalism. Some of these causes are the result of our rapid growth as a city and the high levels of poverty we face. These issues cannot be resolved overnight, as to do so would burden the ratepayers excessively with the cost of the additional capital needed. As an example, to ensure that every family without access to sanitation receives access to an acceptable basic sewage disposal system, will cost over R1,5 billion.

The upgrading of the city's sewerage system takes the form of extending the sewerage service to all communities and this work will not be completed until 2012 or 2013. In 1996, 250 000 families in the municipality did not have access to acceptable sanitation. Since that time over 20 000 families have been connected each year. This service delivery has been offset to some extent by the large inward migration of families into the municipality seeking access to basic services and employment. By photographing the municipal area every year and counting the houses on the ground, it has been possible to measure this influx, which has reached 30 000 families in a single year on occasions.

To respond to illegal connections between sewer and storm water systems on private property, we have started to make use of smoke generators which pump smoke into sewers and this smoke will exit from any storm water drain that is connected to it, making detection somewhat easier. It is almost impossible to detect intermittent interconnections that are made during storm events when sewer manholes are opened to relieve local flooding.

Sand from the harbour itself has recently been pumped onto the beaches, instead of sourcing sand from the open sea south of the south pier, as used to be the case. It is necessary to continually pump sand onto the central beaches to prevent them from eroding away. Reports were received from the public that this sand smelt of sewage and it was found to be contributing to the contamination of the sand on the beaches. Since January, this pumping has been stopped and the sand quality will improve over time.

To reduce the impact of storm water drains discharging onto the beaches of the golden mile, we have begun to construct sumps in all nine of these drains and pump the contaminated low flows that arise from time to time into the nearest sewer. Two of these drains already have the sumps in place. It is a reality in a large city like ours, that poor people and vagrants do not always have ready access to toilets, or do not make use of these facilities when they are available. This drain intercept initiative will enable us to wash the city streets more often, knowing that the effluent that is generated will be collected and treated properly.

The frequency of testing of the water and sand microbiology has been increased to once a week and shortly we will display the results of these tests on notice boards on our beaches, as well as on the internet on a weekly basis, together with a litter index to indicate the cleanliness of all our beaches. These results continue to show compliance with DWAF (Department of Water Affairs and Forestry) water quality standards, except for a few days after significant storm events at beaches close to rivers or storm water drains.
WITH PLACES OF natural beauty in high demand for both residential and commercial reasons, and following an environmental impact study, IMESA (Institute of Municipal Engineers of Southern Africa), in conjunction with the municipality of Saldanha Bay, has established the Saldanha Bay Forum. This body was created to preserve Saldanha Bay, the Langebaan Lagoon and the immediate inland surrounds, and also to promote sustainable development for the bay and coastal areas.

According to Piet Fabicius of Environmental Health Services (Saldanha Bay Office), environmental scoping had indicated the need for a forum to monitor the environmental impact of users on the bay. However, it was felt that such a forum need not be a formal statutory authority. Therefore the Saldanha Bay Forum is an ad hoc, consensus-seeking body performing an advisory function.

The proposal to construct a temporary groyne at Langebaan and the need for beach dredging to combat beach erosion were both instigating factors surrounding the establishment of the Forum. According to Fabicius the founding of the Forum was met with much support and enthusiasm by stakeholders and users of the bay.

The Forum focuses on several geographical areas, including the water area of Saldanha Bay and the Langebaan Lagoon, the coastal zone, as well as the immediate hinterland and inland areas where there may be issues that could impact on the bay and its surroundings.

The Forum’s main objectives are to:
- be a vehicle which is representative of all the bay stakeholder groups
- provide a mechanism for the exchange of information
- monitor the management and health
of the bay area, as well as initiate and guide research on it.
- provide a forum for dialogue and debate
- provide advice and support to regulatory and governmental bodies responsible for the management of the bay.

The bay is used on a daily basis for different purposes – industrial, business, tourism, marine-culture, recreation – by various groups of people. These groups greatly benefit from the many opportunities that the bay has to offer, including export and import, harvesting of seaweed and shellfish, and water sport.

However, these users’ diverse needs in turn have a diverse impact, both existing and potential, on the bay environment. The bay, with its highly industrialised Port of Saldanha, is a marine-protected area and forms part of the West Coast National Park. The environmental consequences of users’ activities have led stakeholders and users to identify the need for urgent joint and strategic integrated management of the bay.

According to Martiens Victor of IMESA in Saldanha Bay, IMESA encourages endeavours such as the formation of the Saldanha Bay Forum and would like to see more municipal initiatives nationally around environmental impact and sustainability.

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Legal obligations regarding the lifecycle of a mine tailings storage facility

BACKGROUND
Since the promulgation of the Minerals Act in 1991, all mines have to a large extent been forced to act with greater responsibility to address and mitigate all the potential impacts their activities may have on the environment. The National Environmental Management Act (NEMA) and the National Water Act (NWA), promulgated in 1998, have given further impetus to this national drive.

The principle of 'Duty of Care' enshrined in Section 28 of the National Environmental Management Act (No 107 of 1998), enjoins a statutory obligation on companies and operations to take reasonable measures to prevent pollution or degradation from occurring and, if it cannot reasonably be avoided or stopped, to minimise such pollution to the environment.

In addition, Section 38 of the Mineral and Petroleum Resources Development Act (MPRDA), 2002, makes provision for the directors of a company or members of a close corporation to be held jointly and severally liable for any unacceptable negative impact on the environment.

It is clear then that there is an urgent need for mining activity to be planned in such a way as to ensure the minimum impact on the environment. Arguably, the greatest potential source of mine-related pollution is mine tailings dams.

Increasing pressure is being placed on mining companies to improve their environmental performance. The abundance of abandoned mine sites and large tracts of unrehabilitated mine land on the Witwatersrand and the Natal and Mpumalanga coalfields testify to the fact that mining companies have in the past failed to apply sustainable closure principles, particularly regarding tailings deposits. To be successful in an increasingly competitive global market, it is vital that mining companies subscribe to the principles of sustainable development. The very finite nature of mining requires responsible planning and effective management to meet sustainable closure objectives. The prevailing legislation specific to the lifecycle of a mine tailings dam is summarised here.

Let us examine briefly all the legislation relevant to the lifecycle phases of a typical mine tailings dam. The principal phases are:
- Planning
- Design and construction
- Commissioning and operation
- Decommissioning
- Rehabilitation and closure
- 'Post-closure' management of residual and latent impacts

LEGAL RESPONSIBILITY
A weighty responsibility is placed on company directors, managers and even personnel to act in an environmentally responsible manner at all times. Of particular significance is what has come to be commonly known as the 'polluter pays' principle which is contained in Chapter 1 of the National Environmental Management Act, 1998 (NEMA) and endorsed in Section 37 of the MPRDA:

“The costs of remediying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimizing further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment.”
LEGAL OBLIGATIONS PERTINENT TO THE VARIOUS LIFECYCLE PHASES
Planning
First, a preferred site for the tailings dam must be selected according to criteria specified in MPRDA Regulation 73, followed by geotechnical and ground water investigations. No person may temporarily or permanently deposit any residue stockpile or deposit on any site other than on the one demarcated for that purpose (MPRDA Section 42).

There are also restrictions on cultivating virgin soil (Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA) and amended Regulations); on cutting or damaging protected tree species (National Forests Act, 1998, and Govt Notice No 897 of 8 September 2006); on siting with regard to the 1:100 year flood-line or a specified horizontal distance from any water resource; on disposal of residue in any place likely to cause pollution of a water resource; and on the use of materials for constructing a tailings dam that are likely to cause pollution of a water resource (the last three stipulated in Govt Notice 704, June 1999).

Concerning Environmental Impact Assessments (EIAs) and the Environmental Management Process (EMP), the National Environmental Management Amendment Act, 2004, enables a system of EIAs and related management tools to be regulated in terms of NEMA, in addition to the impact assessment requirements of the MPRDA 2002. Regulations pertaining to the NEMA EIA process and addressing the process of either basic assessments or EIAs were published as Govt Notices R385; R386 and R387 in April 2006.

Obligations for public participation are likewise contained in the relevant sections of the MPRDA and regulations.

Design and construction
Govt Notice 704 of June 1999 stipulates that every person in control of a mine or activity must confine any unpolluted water to a ‘clean water system’, operate such a system at the mine so that it is not likely to spill into any dirty water system more than once in 50 years, and collect the water arising within any dirty area, including water seeping from mining operations, into a ‘dirty water system’. The serviceability of conveyances for such flows must also be guaranteed.

MPRDA Regulation 73 deals with the management of residue stockpiles and deposits. The assessment of impacts relating to these must form part of the EIA and EMP. Mine residue must be characterised to identify any potentially significant health or safety hazard and any environmental impact of the stockpiled or deposited residue. A risk analysis must be carried out and documented on all high-hazard residue stockpiles and deposits. Furthermore, a design report and operating manual must be drawn up for all residue stockpiles and deposits.

The National Water Act defines different water uses in Section 21 and water use licences and the registration of dams with a safety risk in Section 22.

Commissioning and operation
Occupational health and safety plays a major role during commissioning and operation and is regulated in terms of the Mine Health and Safety Act, No 29 of 1996 (MHSAs).

According to the MPRDA Regulations, the holder of a mining right must conduct monitoring on a continuous basis, conduct performance assessments of the EMP as required, and compile and submit a performance assessment report to the Minister (Regulation 55). The principles of pollution control and waste management are covered in Regulations 63 to 73, which deal with the management of air quality, noise, water and pollution control.

Other legislation relevant to commissioning and operation is contained in the National Water Act (emergencies, security, temporary or permanent cessation of a mining operation, and technical investigations and monitoring); the National Environmental Management Act, 1988; the National Nuclear Regulator Act, 1999 and the Atmospheric Pollution Prevention Act, 1965. The National Environmental Management: Air Quality Act, 2004, deals with the control of dust and re habilitation when mining operations cease.

This is not the end of the list! Also to be adhered to are the appropriate chapters and regulations of the Conservation of Agricultural Resources Act, No 43 of 1983 (CARA) and amended Regulations (15 and 16) of March 2001 and the National Environmental Management: Biodiversity Act, No 10 of 2004, both of which cover the management of alien and invasive plant species. The National Veld and Forest Fire Act, No 101 of 1998, governs requirements for firebreaks and the Hazardous Substances Act, 1973, and Regulations contains requirements pertaining to the use of artificially produced isotopes, typically as density gauges in residue disposal pipelines. Additionally the MHSA 96 requires mandatory Codes of Practice for mine residue deposits and cyanide management.

Decommissioning, rehabilitation and closure
Statutory obligations in terms of the approved EMP and closure plan have to be abided by. The transfer of environmental liability is covered in Section 43(2) of the MPRDA, which, in contrast with its predecessor, the Minerals Act, 1991, makes provision for the transferring of environmental liabilities to a “qualified person” (Regulation 59). Liabilities in terms of the EMP/closure plan may be transferred, provided an application is lodged with the Minister for approval and subsequent to endorsement in writing by the Department of Water Affairs and Forestry (DWAF) and the Chief Inspector of Mines.

Further, all the acts and notices referred to above also contain provisions relevant to decommissioning and closure of mining operations.

Post-closure management
The granting of a closure certificate as contemplated in Section 43 of the MPRDA does not imply that a ‘walk-away’ will be possible. Section 43(6) stipulates that: “When the Minister issues a certificate, he or she must return such portion of the financial provision contemplated in section 41 as the Minister may deem appropriate to the holder of the prospecting right, mining right, retention permit or mining...
A weighty responsibility is placed on mine management to ensure that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource within the framework of sustainable development.

permit concerned, but may retain any portion of such financial provision for latent and or residual environmental impact which may become known in the future”.

**Socio-economic impacts**

Responsible closure, concomitant with the MPDRA, also requires that the socio-economic impacts be addressed, managed and wherever possible, mitigated and eliminated. Regulations published in terms of the MPDRA require that all mining companies have a Social and Labour Plan in place. This plan should consider the development of a mining operation in the context of generally recognised standards of sustainable development by integrating social, economic and environmental factors in planning the mining operations throughout the life of the mine, and on closure. Sustainable closure therefore involves far more than mitigating or eliminating the risks and impacts on land, water, the atmosphere, micro-organisms, and plant and animal life. Closure can never be sustainable if socio-economic impacts are not identified, addressed and accounted for.

**CONCLUSION**

A weighty responsibility is placed on mine management to ensure that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource within the framework of sustainable development.

Turning these potential liabilities into a sustainable asset after closure probably presents the biggest challenge to mining companies. Responsible and active planning for closure during the life of the operation, with the active implementation and management of engineering and environmental controls, is probably the only way to ensure that post-closure liabilities are quantified, fully understood and managed both responsibly and cost-effectively.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008.
IN RECENT DECADES the detrimental environmental effects of uncontrolled disposal of tailings and the occurrence of several major failures have led authorities worldwide to demand that residue storage facilities should be properly designed, operated and closed. Ever more stringent standards have been imposed on mine owners worldwide. Foreign owners sometimes insist that the standards applicable in their home countries should be applied also in South Africa, despite our well-established mining traditions and legislation, resulting in unnecessarily conservative or expensive facilities. This does not imply that standards should be lowered just because a mine is situated in a developing country, rather it is advocated that the most appropriate standards for a particular situation be used.

A selection of published guidelines is available from the editor.

REGULATORY ENFORCEMENT AND ENVIRONMENTAL PROTECTION STANDARDS

Mine waste facilities in South Africa are required to be constructed and operated in accordance with several different acts of legislation, some of which may at times appear to be contradictory. There is no single statute, act or regulation in South Africa dealing specifically with the construction, operation and decommissioning of mine residue facilities. Legislation that must be observed includes the Mine Health and Safety Act, the National Water Act, the Mineral and Petroleum Resources Development Act and the National Environmental Management Act.

Mine waste disposal in South Africa is generally carried out in accordance with SANS 10286, (previously SABS 0286), the Code of Practice for Mine Residue. SANS 10286 provides a guideline as to what legislation must be complied with, summarises the key legal requirements pertaining to mine residue and outlines the principles to be followed in the management, planning, siting, design, construction, operation, decommissioning and aftercare of residue deposits.

South African authorities generally adopt a risk-averse approach in granting licences to mining developments, bearing in mind the fact that such developments should be socially, economically and environmentally sustainable. This same approach should be adopted elsewhere on the African continent. The principle frequently applied to mine waste management is the BATNEEC principle: Best Available Technology Not Entailing Excessive Cost.

Whatever legislation and environmental protection standards are applied in a particular country should take into account the overall economic situation and objectives of that country, in addition to the primary concerns of safety and protection of the environment. The published guidelines generally note that the solutions to be applied must be site-specific.
The design life for operation of a mine waste facility is generally taken as no more than 20 years, sometimes less, irrespective of the mineral or resource reserve available. It is unrealistic to forecast the economic viability of a mine beyond a 20-year horizon. However, when environmental effects are considered, due attention must be paid to the sustainability of the facility after closure and for the long-term future. In South Africa we are used to thinking in terms of 50 or 100 years, but in countries like Canada and the USA a time horizon of 1000 years is mandated.

**STABILITY CRITERIA**

**Factors of safety**

In South Africa it is common to design for a minimum factor of safety (FoS) of 1.3 against slope failure under static conditions while the facility is in operation and under regular surveillance, increasing to 1.5 after closure. For transient or seismic conditions, a minimum FoS of 1.1 is usually specified, but may be modified under particular circumstances.

These criteria are not out of line with generally accepted international standards. In most of South Africa, however, the climate is temperate semi-arid to arid and seismic risk is generally low, which means that the required FoS can be achieved with simpler methods of construction than in regions with significantly higher rainfalls, more extreme temperatures and higher seismic risk.

**Acceptability (or otherwise) of upstream construction**

Most South African tailings storage facilities are constructed by the upstream method, in which the outer confining wall or embankment is constructed over previously deposited tailings. In most cases the confining wall itself consists of tailings, whether it is constructed by cycloning, spigoting or by the ring paddock system.

Because of their experience in their home countries, overseas-based mine owners are sometimes reluctant to accept upstream-constructed tailings storage facilities, even where the method can be demonstrated to result in a stable deposit, despite the lower capital cost usually associated with this type of facility.

**Seismic loading**

The Design Basis Earthquake (DBE) is commonly specified as that seismic event with a 10% probability of being exceeded in 50 years (or 100 years in some standards) – equivalent to a recurrence interval of 475 years (or 950 years) for the DBE. Under these circumstances the slope must remain fully stable. Sometimes, even though the minimum specified FoS of 1.1 is not achieved, the design may be satisfactory, provided that it is shown that the estimated deformations due to seismic loading are acceptably small.

Under the Maximum Credible Earthquake (MCE), which may be a 1 in 10 000 year event, some damage would be acceptable, but not complete failure of the slope or any other component of the tailings storage facility.

**WATER MANAGEMENT SYSTEMS**


GN R704 states, inter alia: “Every person in control of a mine or activity must … design, construct, maintain and operate any clean (and dirty) water system at the mine or activity so that it is not likely to spill into any dirty water system more than once in 50 years; and … design, construct, maintain and operate any dam or tailings dam that forms part of a dirty water system to have a minimum freeboard of 0.8 metres above full supply level…”

GN R577 states, inter alia: “Design considerations as applying to the particular type of stockpile and deposit that must be incorporated include –

- the control of storm water on and around the residue stockpile or deposit by making provision for the maximum precipitation to be expected over a period of 24 hours with a frequency of once in 100 years.”

Australian practice is to design for the 1 in 100 year 72-hour rainfall event. In the Americas return periods of up to 1 000 years have been specified.

Because the confining walls of most South African tailings storage facilities are constructed of the tailings material itself by the upstream method, the freeboard is usually relatively small and it is not considered good practice to retain large quantities of water on such facilities. It is therefore necessary to remove supernatant and rain water from the facility and store it elsewhere, usually in a separate return water dam which is specifically designed for that purpose. The return water dam is constructed and operated so as to ensure that there
is always sufficient spare capacity to contain storm water runoff from the tailings storage facility, as required by GN R704 and GN R577.

In South Africa it is common for the decanting system to be by means of a gravity penstock discharging through a pipe through the confining wall. Pumping systems are less commonly used. In many parts of the world, however, it is considered poor practice to have any kind of pipe penetrating the confining wall and pumped decant systems are almost always used, with the water returned directly to the process plant. In high rainfall zones where the confining walls are built ahead of the tailings beach and pool, the design may allow for large quantities of water to be held on the tailings dam without compromising its stability.

PREVENTION OF SURFACE AND GROUND WATER CONTAMINATION; LINING OF TAILINGS STORAGE BASINS

Major funding agencies in many countries, and South Africa, mandate a policy of “total containment of polluted water”. Nevertheless, there can be significant differences in the interpretation of this requirement. Also, account should be taken of the natural background concentration of the elements that could be released.

‘Pollutants’ need to be clearly defined, as not all dissolved salts are necessarily harmful to the environment. Although, of course, chemicals such as cyanide and arsenic are poisonous, and radioactive wastes from uranium mines are highly hazardous, the World Health Organization (as well as South African regulations) has specified concentration limits for most substances, below which they can be regarded as not injurious to health.

What is the design implication of “total containment”? In South Africa, GN 704 permits spillage of dirty water to the environment no more than once in 50 years, which is based on the premise that for a rainfall event with a recurrence interval exceeding 50 years there will be sufficient water in the receiving environment to ensure adequate dilution of any pollutants. However, there is the view that “dilution is not the solution”. Although the immediate concentration of a particular pollutant may be below the specified limit, certain substances can be very persistent and their concentration in the receiving body of water may increase with time to hazardous levels.

When applied to groundwater seepage, the principle of “no release of pollutants” implies that there should be a fully effective barrier beneath a tailings storage facility to prevent seepage. Although this has not been the case in South Africa, the provision of synthetic liners has been common practice overseas for several years. The choice of barrier depends on the chemical constituents in the seepage, the geological environment, the available liner materials and their properties. Bear in mind that all liners (natural or synthetic) leak to a greater or lesser extent and will only reduce the seepage.

FULL CLOSURE DESIGN

The approach to designing for closure of a mine waste facility is in essence the same – whether it is done in South Africa or overseas. The difference lies in the 1 000-year and 50-year recurrence interval design criteria. Capping designed for 1 000-year recurrence interval rainfall will need to be thicker and more robust than capping designed for 50-year rainfall. The design of erosion-protection measures and storm water channels must fully consider climatic factors, bearing in mind the high flows associated with the greater intervals and that maintenance and repair of the facilities cannot be assured over such a long period.

CONCLUSION

As a whole, the design standards and criteria used internationally are becoming far more onerous on the owner, designer and operator of mine waste facilities than has previously been the case. In the long term, the adoption of these criteria in new African mining developments can only benefit the mining industry and environment. However, it is important that overseas or First World standards be implemented judiciously, and that they be applied in a manner appropriate to the particular situation.

REFERENCES

Please contact the editor for the list of references

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008
Addressing the social impact of mining activities on communities for sustainability

It is very important to consider the social impacts of mining activities on the surrounding socio-economic environment, and to incorporate Social Impact Assessment (SIA) into the operational activities of a mine as a management tool. However, the practice of SIA by mining companies is often largely lacking, especially in the developing nations of the world. To avoid such socio-economic marginalisation by mining companies, the government of South Africa requires mining companies to develop and implement Social and Labour Plans (SLPs), which focus on promoting the long-term development of their workforces, employee households, communities and regions.

From the day a mining operation starts, it is immediately in a closure phase, counting down the clock until that inevitable day when the doors will close. Once mines close, the social impacts on employee households, communities and regions are mostly severe and long-term. Ghost towns develop in areas that were once heavily reliant on mining for economic sustainability. The majority of the people who were dependent on the mining operation for income are usually left stranded in an area that they cannot escape from.

There is also often a lack of proper planning in the placement and rehabilitation of mine infrastructure, land and waste dumps in considering the future social and economic impact on communities and development for the region. After closure, mine waste deposits and unproductive, disturbed land are often left behind, which precludes the productive use of economically valuable land for the socio-economic development of communities over the long-term.

Importance of the Social Impact Assessment (SIA)
Mining development in the past has characteristically been synonymous with a disregard for its social impacts and affected communities. In many instances, mining companies have invested huge amounts of capital in African countries for mining development, openly stating that they are contributing to socio-economic development at a grass roots level. In reality, however, communities in the developing world have usually been completely bypassed by any development benefits from the project and are often left in a marginalised state, in which they are far worse off than before the mine opened.

Surrounding communities generally develop around a mine and become dependent on the economic opportunities generated by it, especially within isolated rural areas. Apart from these dependencies and economic impacts, the social impacts are usually felt even more, i.e. squatting and low living standards, social ills, disruption of traditional lifestyles and livelihood systems, increase in violence and crime, idleness and a disregard for traditional culture.

The challenge is to come up with innovative land uses, closure scenarios and waste management solutions that can pro-
mote sustainable development in affected communities.

Recent legislation in South Africa, such as the Broad Based Socio-Economic Empowerment Charter (BBSEE C) for the Mining Industry and the Mineral and Petroleum Resources Development Act (MPRDA) have confirmed the requirement for mining companies to assess the social impacts of their activities from start to closure, and beyond. Unless a mining operation has considered the social impact and documented it, the Department of Minerals & Energy (DME) will not issue a mining right to the applicant (MPRDA Regulations, 2002). Mining companies also have to compile and implement a Social and Labour Plan (SLP) to promote socio-economic development in their affected communities and to prevent or lessen negative social impacts. Moreover, monetary institutions, such as the World Bank, will also not fund mining projects unless detailed social studies are undertaken.

These are key challenges for the mining industry, which must be incorporated into each mine’s planning and operational processes.

KEY ASPECTS OF A MINING SIA
Some of the potential socio-economic impacts resulting from new and existing mining operations and from eventual mine closure are:

- The extent of general development in the area as a result of infrastructure and services provided by the mining operations, e.g. electricity, healthcare and transport
- The economic changes that may occur or have occurred as a direct result of the opening of the mine, e.g. economic returns to local settlements through royalties and mine taxes
- The likely direct economic changes that may occur as a result of the mine closure, e.g. loss of jobs at the mine and the impact of such changes on the local community
- The extent to which skills and enterprises in the local economy are dependent on the mine and its activities; influences from outside; interventions by government, industry, NGOs, etc
- Cumulative impacts on the regions, i.e. the impact of the migrant labour system on labour-sending communities
- Cumulative impacts due to the development of numerous mining waste deposits in a given area
- An analysis of alternatives for closure regarding infrastructure, livelihood projects, etc, and for land use for the establishment and re-mining of tailings disposal facilities

PURPOSE OF AN SIA
The SIA focuses on the identification and mitigation of both positive and adverse social impacts that may arise from a given project, such as the establishment of a mine. It usually forms part of the Environmental Impact Assessment (EIA) process, but has often played much less of a role than the biophysical assessments.

The main aims of an SIA are:

- To understand the socio-economic characteristics and baseline of the area that will be impacted by a given mining project and how these relate to the dynamics of affected communities and economies
- To identify the stakeholders, including landowners, farm residents, government and tribal institutions, businesses, NGOs, etc
- To undertake a detailed Public Consultation Process (PCP)
- To describe the socio-economic issues that may become problematic if not adequately addressed
- To quantify and assess the socio-economic impacts likely to
result from the construction, operation and closure phases of the project and to develop relevant mitigation and management measures to be implemented.

- To describe the existing opportunities for socio-economic upliftment, sustainable enterprise development and community livelihood development, which may act as a trade-off against any socio-economic impacts.
- To provide sufficient information for the compilation of a realistic and logical Social & Labour Plan (SLP).

**THE FOUR BASIC STEPS IN A MINING SIA**

**Step 1: Preliminary assessment and identification of communities (scoping)**

During this phase the mine should undertake a broad analysis of the social environment affected by its operations. All relevant stakeholders within the mine-affected regions should also be identified, i.e. government authorities, NGOs, industry, community-based organisations, etc. A consultation process with interested and affected parties should be initiated in this phase to record the key social issues. A preliminary description of the socio-economic environment, potential social issues and likely socio-economic impacts should be provided, as well as a detailed plan for what will be investigated during the ‘profiling’ stage (or Baseline Socio-Economic Study-Survey).

**Step 2: Baseline Socio-Economic Study-Survey (BSESS) and profiling of the community**

The baseline will indicate the ‘true’ needs and factual information on the mine-affected communities, thereby enabling appropriate identification and quantification of the social impacts, as well as enabling the planning of community development interventions and livelihood-creation initiatives. A BSESS will focus on the mine’s defined employees and households, on its affected communities (including surrounding and labour-sending communities), identified in Step 1, and on the municipal and provincial regions of location.

For the BSESS a questionnaire or interview survey is conducted to collect qualitative and attitudinal data with key individuals, informal leaders, focus groups and others, i.e. a survey with the workforce, a survey with affected community households, etc. The study should provide baseline socio-economic information on local conditions, local knowledge, local attitudes and perceptions. All of this is necessary to be able to assess the potential short and long-term positive and negative effects of the various project alternatives. This step will also include a detailed analysis of the current socio-economic conditions of the broader municipalities and regions impacted by the mine, as well as current sustainable development strategies or initiatives and programmes within these regions.

The information should then be captured into a socio-economic database, which will be used as the basis for analysing the social impacts and for managing and monitoring future development programmes. The database will contain the profiles of the affected communities, relating to: socio-economic status and livelihood profiles; household economic profiles; employment status; agricultural involvement; income streams, home ownership and the state of loan repayment on these homes; household assets; education and skills profiles; health and welfare status; cultural background; demographic information on the population; and perceptions and aspirations.

**Step 3: Assessment of impacts**

Based on the outcome of the BSESS and the issues arising from the community participation process, the positive and negative potential socio-economic impacts are assessed. These impacts should be quantified in terms of:

- extent (local, immediate surroundings, regional)
- nature (what causes the effect, what will be affected, how will it be affected)
- duration (short term < 5 years, medium term = 5–20 years, long term > 20 years, permanent)
- probability (improbable, probable, highly probable, definite)
- status (positive, negative, neutral)
- significance (no effect, low, medium, high, severe).

Apart from a quantitative assessment of the impacts, most of the assessment should focus on providing a clear, descriptive indication of the social impact relationships due to the nature of the data, which are qualitative and based primarily on people. As such, it must be emphasised that it is not easy to measure social impacts and to apply Environmental Impact Assessment methodologies to people.

**Step 4: Formulation of a Community Development Action Plan (CDAP) or Local Economic Development Plan (LEDP)**

Based on the BSESS and the impacts identified in the SIA, a detailed CDAP/LEDP should be formulated indicating how the mine will implement sustainable community development and social upliftment in its affected communities. In the South African context, the CDAP/LEDP will fall under the prescribed SLIP, which is required by the MPRDA and BSESEC for companies undertaking mining projects. The CDAP/LEDP is usually prepared along with the SIA in order to provide a social plan with initiatives that will promote the ongoing sustainability of the community during the window of opportunity created by the mining operation.

The CDAP/LEDP is formulated in conjunction with government authorities, local communities, other stakeholders and the mining company. The implementation of the CDAP/LEDP should continue after mine closure into the monitoring phase. It should identify opportunities for social development and propose specific projects that may lead to long-term sustainable development in mine-affected communities. Projects should focus on the provision of infrastructure and basic services, and on the eradication of poverty or livelihood development.

**CONCLUSION**

The SIA should not be regarded by mining companies as a moral responsibility, but as a tool to promote sustainability for both the mining company and the affected communities. Managing and assessing the social impacts of mining operations will ensure strong relationships with affected parties and also ensure favour with the governments of those countries, which will equate to economic benefits for all stakeholders. If mining activities are to contribute to sustainable development in their affected communities/regions, the basic SIA methodologies explained here have to be considered as a starting point.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008.
Some rehabilitation issues on Witwatersrand gold tailings dams

FOR MOST MINING operations, water and soil quality are the two most difficult environmental aspects to address when one takes the wealth of South Africa’s mine-relevant legislation and the total extent of both water and soil on a mining operation into consideration. Although our legislation focuses much more on water quality than on soil quality, that is no excuse for neglecting soil quality. If one starts by visualising the end-product of the tailings residue dam (post-closure land use) during the design phase of a mine, it is so much easier to consider alternative design and extraction methods.

TYPICAL PROBLEMS AND THREATS IN GOLD TAILINGS DAM REHABILITATION
What are the real objectives of rehabilitation?

- Surface stability (resistance to wind and water erosion, and spreading of pollution), either permanent (in the operational and closure phases) or temporary (in the operational phase)
- Appropriate post-closure land use (PCLU), which must be: sustainable, cost-effective and financially viable, and resistant to any form of degradation or pollution

Identifying those tailings characteristics that pose a threat to the environment or that could jeopardise the objectives of the rehabilitation and PCLU is a tall order for any environmental practitioner. However, if one distinguishes between the causes, pathways and receptors of the various threats, it becomes easier. A typical example of such a concept is:

Pyrite is the cause, oxidation the pathway and the slopes the receptor

The four fundamental environmental aspects that are important in the mining industry are aesthetics, air quality, water quality and soil quality. There are various designs and management options that could contribute to a greener and better-stabilised tailings residue dam and its surroundings after mine closure. In the case of gold tailings residue dams, slope geometry, acidification and other environmental factors must be considered and these aspects require further investigation.

Table 1: Pyrite – threats, causes and solutions

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of acidity and salinity. The acid slopes (receptor) can be treated by means of liming (pathway), but the pyrite (cause) has to be removed or isolated to prevent acidification.

Therefore one has to address both the oxidation of pyrite (acidification problem) and the steep slopes (pathway and receptor) in the case of old gold tailings dams (see Table 1).

### PHYSICAL AND CHEMICAL ENVIRONMENTS OF GOLD TAILINGS DAMS

Slope geometry (length and slope angle) and acidification were identified in this investigation as the two most significant negative aspects of gold tailings dams.

#### Influence of slope geometry

**Case study 1: Tailings dam 6 (FS6S) (north slope)**

The steepness of the northern slope of the gold tailings dam was decreased from 32° to 18°. However, this increased the slope length from three slopes of 16 m to one slope of 80 m. Although erosion was not measured, it was concluded from observations made over a period of 9 years that the amount of erosion was insignificant because very little sediment accumulated in the toe paddocks. Results from the USLE model (which calculates potential soil loss) showed that a flatter slope is far more stable with regard to sediment transport (erosion), water run-off, vegetation quality and overall stability.

**Case study 2: Tailings dam No FS6S (west slope)**

This was a gold tailings dam with a 32° slope angle and a slope length of 16 m. Three cover types were considered: vegetation, rock cladding (with no geotextile under-cover) and a no-cover design. The run-off and erosion rate were measured for five rain events, and these were extrapolated to 600 mm/year rainfall/hectare.

In this case the results showed that vegetation cover would be more successful than rock cladding with regard to soil retention, but the rock cladding produced less water run-off. However, these differences are insignificant compared with what would occur if the slope had no cover.

Flatter slopes have various advantages:

- It is possible to cultivate the slopes of the tailings dam mechanically, so the amelioration is more effective.
- The seeding process is also mechanical and the seed of species with woolly seed (e.g. Cenchrus ciliaris – blue buffalo grass) can be compacted after being sown.
- Rainfall is more effective on flatter slopes (13% less at 30° compared with 15°).
- The erosion rate increases with increasing slope angle and slope length.
- Water run-off increases with increasing slope angle.
- There is less wind due to wind amplification on steeper slopes.

#### Influence of acidification

Acidification in gold tailings is manifested in many forms. Investigations and research into acidification continuously reveal new problems that have not been encountered or known before. Through assaying, the Fraser Alexander Tailings Environmental R&D team and their main supplier in this field (Geolab), have identified an additional source of acidification in the gold tailings termed ‘latent acidity’. Additional acidification species derived from residual acidification have also been identified.

#### Active and potential acidity

Titration of a filtrate after H2O or KCl extraction of soil acidity is globally the standard procedure for determining active and potential acidity in agricultural soils and also for acid sulphate soils in Australia. This method was tested on Witwatersrand gold mine waste but severely underestimated the lime requirement in a mine waste sample when compared with a laboratory incubation of a mine waste sample with lime. Field observations confirmed this underestimation of active acidity. It is therefore not common practice to analyse for these two acid species in the case of tailings material if pyrite is present.

<table>
<thead>
<tr>
<th>Table 2: Comparison of cover types for gold tailings dam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover type</td>
</tr>
<tr>
<td>Water run-off (kl/ha/yr)</td>
</tr>
<tr>
<td>Soil loss (t/ha/yr)</td>
</tr>
</tbody>
</table>

#### Residual acidity

Sulphuric acid derived from the oxidation of pyrite has been identified by many researchers in the past. The double-buffer incubation analytical method was developed and used by Envirogreen until 2005. Our follow-up research work identified additional acidity from solutions and oxidation products of secondary minerals, e.g. jarosite and schwertmannite. Theoretically, there could be additional sources from other unidentified ferrous sulphate minerals, too. The extraction method for quantifying the extended residual acidity was changed from the double-buffer incubation method to a newly developed method. The new information and procedures led to the...
identification of additional knowledge gaps in the complex behaviour of geo- and pedo-chemistry of the gold tailings.

**Latent acidity**

A study by Gillman & Sumpter (1986) found that the lime requirement was equal to the active acidity (determined by standard filtrate titration) in granite and metamorphic soils, but two to three times higher in the case of basaltic (variable charge) soils. This is explained by the contribution of protons from the clay crystals when the pH of the soil solution increases and in the process the net negative charge of the clay lattice increases. Soils exhibiting this property are often referred to as ‘variable charge soils’ or ‘pH-dependent charge soils’. The material or ‘soils’ from the tailings are very much prone to these phenomena and side-effects when the pH is increased by liming. Similar reactions could also occur wherever rehabilitation of gold tailings footprints is done. To accommodate the neutralisation of this source of acidity, an alternative analytical procedure is required (such a project is in progress).

Follow-up work and research has also revealed that additional electrolytes, i.e. salts (very common in gold tailings), also contribute to the decrease in pH. This is caused by the H+ ions associated with the freshly prepared minerals derived from the electrolyte (salt) by means of dissociation and hydrolysis, e.g.

\[
\text{CaSO}_4 \cdot \text{H}_2\text{O} - \text{Ca}^{2+} + \text{SO}_4^{2-} + 2\text{H}^+ + \text{O}_2^- \tag{1}
\]

These H+ ions are not released from the original chemical reactions, i.e.

\[
\begin{align*}
\text{FeS}_2 + 3.5 \text{O}_2 + \text{H}_2\text{O} &= \text{FeSO}_4 + \text{H}_2\text{SO}_4 \quad \text{or} \quad [2] \\
\text{FeSO}_4 + 0.25 \text{O}_2 + 1.5 \text{H}_2\text{O} &= \text{FeOOH} + \text{H}_2\text{SO}_4 \quad [3]
\end{align*}
\]

The H+ ions could also derive from the fresh but immature edges of the newly formed crystals, e.g. jarosite, or from the broken edges of matured crystals, e.g. weathered mica or feldspars, in the tailings. Both these two phenomena are based on the thickness of the so-called ‘diffuse double layer’ which is dependent on the electrolyte concentration.

The formation of oxide minerals, i.e. ferrous oxides, is very common in gold tailings, e.g. goethite (FeOOH) and hematite (Fe₂O₃). Unfortunately, they have amphoteric properties, that is to say, depending on the pH of the total system, they could be either negatively or positively charged. If negatively charged, they could adsorb H+ ions from water hydrolysis and exhibit additional sources of acidity.

These three newly identified acid species have what is termed ‘latent acidity’ due to the fact that the chemical behaviour of the system (pH-dependent charge), the electrolyte concentration and the presence of oxide minerals could change from time to time, hence the variability in the production of acid from these sources.

Field studies reveal that real acid mine drainage (AMD) from tailings dams is restricted to the outer superficial rind of the tailings dam, as shown in Diagram 2. Modelling shows that the oxidation rate in the core could take more than 1 000 years to reach the bottom of the tailings dam. This phenomenon results in extreme infiltration and seepage of AMD around the toe of gold tailings dams, with a relatively inactive core. If one could counteract the infiltration of AMD into the ground-water system around the toe by using dolomite or artificial liners, the main problem would be solved for many years.

**Influence of other environmental factors**

A number of other environmental factors influence the rehabilitation design:

- The type of soil on the proposed footprint – the infiltration rate, pH, EC, clay content, buffer capacity and neutralisation effect
- In the case of bedrock – the infiltration
rate, preferred pathways, lithology (carbonate or not), solution cavities, CCE and heavy metals
- Tailings mineralisation – the pyrite content, heavy metals content, etc
- Unsaturated flow in tailings dams (dormant or abandoned dams) – such flow by means of diffusion is poorly defined at present, but may have significant negative effects

MAJOR KNOWLEDGE GAPS

The rehabilitation of a tailings dam creates a new ecosystem. Since the new ecosystem (which requires monitoring and maintenance programmes) will have specific or unidentified plant dynamics, microbial activity starting from zero, ongoing active geochemical reactions and soil physical processes, it will be a more complex system than many natural ecosystems.

Such a new system is extremely dynamic and vulnerable to internal and external changes. The influence of steep slopes on vegetation performance, e.g. its wind tolerance, has not been very well investigated and needs more attention. A major mindshift is required to understand the whole picture, e.g. unsaturated water flow in the tailings complex, ongoing geochemical reactions and the interaction of these with vegetation and microbial activity. A series of geochemical reactions supported by soil physical processes (new in the case of tailings deposits) has resulted in many tailings dam failures and, if they are hidden from all, these failures will continue and create more conflict than ever before between mining houses, consultants, contractors and legislators. It is recommended that everybody in the gold tailings industry should familiarise themselves with the scientific realities and realise that long-term ongoing acidification and salination are inherent in gold tailings in South Africa.

CONCLUSIONS AND RECOMMENDATIONS

These can be summarised as follows:
- Identification and evaluation of all attributes, material characteristics and design parameters should be done upfront to determine the environmental risks associated with a tailings residue deposit.
- Interaction between the different attributes could amplify some of the other attributes; therefore potential interactions should be scrutinised to identify and evaluate other negative characteris-

REFERENCES


The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008

Diagrammatic illustration of the oxidation and un-oxidized zones on a gold TDF and the zones of anticipated AMD

Poorly vegetated gold tailings dam with severe erosion and AMD seepage

Well exposed oxidation zone on a gold tailings dam facility
Selecting the right tailings disposal solution – a case study

The optimal tailings disposal solution for a mine is not always straightforward or necessarily what has been done before. After completion of a feasibility study based on past practice, a comparative study of alternative tailings disposal systems was done for a proposed medium-sized platinum mine considering uniquely developed spigot, cyclone and paste disposal options. The comparative study dictated the consideration of total tailings disposal costing over the proposed life of the mine, revealing the real costs. In this instance, make-up water costs were found to be the most significant, and consequently the paste option was favoured. The lesson learnt from the study is that the right choice is not obvious and that relatively detailed studies are needed.

THE REGULATORY PROCESS to exploit a mineral resource requires, amongst others, a mining authorisation. The process of obtaining such an authorisation is initiated by the submission of a Mine Works Plan (MWP) and to ensure timely authorisation, relatively comprehensive scoping of the proposed project has to be done before the full optimisation studies on possible alternatives. This is particularly true of the tailings disposal, where the ‘site’ is often designated by the mining team on the pretext that it is just ‘preliminary’ to get the MWP into the system. The downside of doing this is that changing from the ‘preliminary’ site (and method of disposal) at a later date is difficult as mindsets and expectations have already formed and sometimes the authorisation has to be amended.

The second sacred cow of mining projects is ‘proven technology’. Very few are willing to be a ‘technology guinea-pig’, requiring their projects to be based on proven, conservative technology. The downside to this is that a number of potentially beneficial opportunities for improvement, or a competitive edge, are missed.

Both initially and ultimately, the proposed development of the medium-sized mine project was no different, but circumstances allowed the investigations into the development of the tailings solution to take a different course during the study phase.

PROCESS OF SELECTING THE TAILINGS SOLUTION

After initial planning, a site selection process and feasibility study for the tailings disposal was commissioned by the prospective owners. The feasibility study proposed a conventional spigot tailings dam as has been used on most platinum mines in South Africa for the past four decades.

Since this was an underground mine, the project had a long lead time which allowed another look at the tailings disposal. The owners were persuaded to allow a comparative study of alternative tailings disposal solutions for the project to be undertaken.

COMPARATIVE STUDY

The ore body in question and the exploitation plan are predicted to sustain the mine for about 20 years at 115 000 tpm, making it a small to medium-sized underground operation. The operation will be sustained with water from the irrigation canal emanating from the Loskop Dam, making the water a limited and costly commodity.

Three alternative solutions were considered, namely:
- a redevelopment and optimisation of the spigot solution to ensure a relevant base case
- a cyclone dam
- a paste solution

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beric@fraseralexander.co.za
The cyclone dam wall was designed and analysed to ensure the viability of a combination of upstream and downstream phases, so creating a wall of adequate dimension over the life, which ensures stability and freeboard while maximising the rate of rise.

Site location
A gently sloping (5%) colluvial plain adjacent to the proposed process plant had been selected as the most suitable site for a spigot dam and this site was retained for the comparative study.

The objective of the fourth-generation cyclone solution was to take advantage of the higher possible rate of rise to minimise the footprint and so reduce surface area and evaporative losses. The particle size distribution indicated only about 20% of >75 micron material suitable for the development of an underflow wall. This would usually be insufficient to develop even an upstream ringdyke dam, so advantage had to be taken of the natural topography to provide containment where possible. Consequently, the cyclone option was tucked into a corner of the plain abutting some of the surrounding steep hills, thereby saving about 40% of the walls.

Owing to the ‘unproven’ paste transport technology, paste was only considered in this instance because the topographic setting could eliminate pumping. The relatively high, steep hills adjoining the gentle plain would allow discharge of the paste from the paste thickener directly above the tailings disposal area without the need for positive displacement pumps. The paste thickener was therefore strategically located on the side of a hill with the projected tailings disposal facility (TDF) fanning out around the hill and across the plain below.

Thus a unique optimal location was identified for each option, illustrating the way in which the different disposal options are specific to the different topographies.

Landforms
The footprint of each solution was optimised on the selected sites to ensure no bias in the comparisons. The spigot dam was sized to accommodate the required disposal volume and a dual-compartment facility was proposed to optimise the volume of the starter wall earthworks in relation to the rate of rise. The plan was for the upper compartment to be overtaken by the lower one to optimise operating costs over the life. The final landform would be a sidehill dam with 1:3 slopes and an almost level upper surface, as shown in Figure 1.

The cyclone dam wall was designed and analysed to ensure the viability of a combination of upstream and downstream phases, so creating a wall of adequate dimension over the life, which ensures stability and freeboard while maximising the rate of rise.

<table>
<thead>
<tr>
<th>Table 1: Alternative options statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect</td>
</tr>
<tr>
<td>Footprint area</td>
</tr>
<tr>
<td>Total height</td>
</tr>
<tr>
<td>Maximum depth</td>
</tr>
<tr>
<td>Slope</td>
</tr>
<tr>
<td>Av. rate of rise</td>
</tr>
</tbody>
</table>
combination of upstream and downstream phases, so creating a wall of adequate dimension over the life, which ensures stability and freeboard while maximising the rate of rise. A circular wall, in plan, was specified to blend into the landscape. Side slopes of 15° (1:4) overall were selected and a rear wall to close off the saddle was also required (see Figure 2).

Bench-scale tests were done on samples of the proposed tailings to establish the feasibility of pursuing paste as a viable option. The tests indicated 68% solids as a feasible underflow density and, together with a specific gravity of 3.5, a hypothetical slope of 1:15 was adopted for the TDF modelling. The optimal position for the central discharge was determined, together with a secondary discharge point some 300 m downslope, which could be reached with centrifugal pumps, to provide operational flexibility to control the drying of alternately deposited layers. The resulting deposit wraps around the hill, spreading out over the plain, as shown in Figure 3. Table 1 compares the options.

**Comparative water balances**
The average, maximum and minimum monthly rainfalls for the area were superimposed on the geometry at different stages of development over the life. For comparison, battery limits had to be inclusive, commencing with the slurry leaving the process plant before any thickening. The water balances were expressed in terms of water losses. The hydrological models were developed on a comparative basis, with the spigot option perhaps being the most optimistic when compared with actual water recoveries on other spigot dams. The results are shown in Figure 4.

**Infrastructure**
The infrastructure that would be necessary to implement the solution (access roads, earthworks, electrical power reticulation, etc.) was ‘designed’ to a comparative level for each option.

**Rehabilitation and closure**
The closure objective for each option was set to just return the final surfaces to wilderness areas, requiring topsoil stripping, stockpiling, replacing and vegetating.

**COST COMPARISONS**
This was the acid test for the comparative study. Most such studies limit the cost estimating to the TDF design and operating costs are generally rough estimates which exclude power consumption, reagent and water make-up costs, thus very rarely indicating the total cost of tailings disposal for a mine. For a true comparison, the study costs had to be fully inclusive.

Quantities for the infrastructure were determined from typical details and general layouts. Capital construction costs were provided by a contractor experienced in this field, but based on off-the-shelf vendor prices. Operating costs included projected maintenance and replacement of all mechanical and electrical equipment over the life, as well as outsourced management costs. Rehabilitation costs were based on specifications of soil coverage, conditioning and vegetation. Power costs were based on the calculated consumption at a specified project kW/h rate. Water make-up costs were also based on a project-specified unit cost of R4/m² and the losses determined from the water balances.

The comparative costs are indicated in Table 2.

**DISCUSSION**
Table 2 and Figure 5 reveal some interesting information. Perhaps most significantly, the original projection of the tailings costs based on the feasibility study was in the order of R30 million. Operating costs were estimated at about 75 c/t, giving a total cost of just less than R50 million. However, it was found that the more realistic total cost would be in the region of R200 million, or between R6 and R8/t, and this changed the mindset of the project team, enabling more accurate financial modelling.

Furthermore, over the life, the significant costs were revealed to be the construction and operating costs (commonly understood) and the maintenance and water make-up costs (very rarely considered in the cost of the solution).

![Water Losses](image)

**Table 2: Comparative life of TDF total costs (rand – 2006 terms)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Spigot</th>
<th>Cyclone</th>
<th>Paste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>2 095 000</td>
<td>2 095 000</td>
<td>2 095 000</td>
</tr>
<tr>
<td>Prof. oversight</td>
<td>3 452 000</td>
<td>3 668 000</td>
<td>4 906 400</td>
</tr>
<tr>
<td>Construction</td>
<td>46 646 194</td>
<td>36 393 113</td>
<td>44 530 654</td>
</tr>
<tr>
<td>Maintenance</td>
<td>35 633 408</td>
<td>43 636 797</td>
<td>33 593 589</td>
</tr>
<tr>
<td>Flocculent</td>
<td>8 942 400</td>
<td>8 942 400</td>
<td>8 942 400</td>
</tr>
<tr>
<td>TDF Operation</td>
<td>52 650 864</td>
<td>57 867 264</td>
<td>31 646 160</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>4 261 000</td>
<td>3 053 400</td>
<td>5 662 500</td>
</tr>
<tr>
<td>Power</td>
<td>7 458 429</td>
<td>7 524 119</td>
<td>12 395 304</td>
</tr>
<tr>
<td>Water make-up</td>
<td>60 653 568</td>
<td>42 847 808</td>
<td>31 034 534</td>
</tr>
<tr>
<td>Total</td>
<td>R221 197 863</td>
<td>R205 432 901</td>
<td>R174 211 541</td>
</tr>
<tr>
<td>Water losses m³</td>
<td>15 163 392</td>
<td>10 711 952</td>
<td>7 758 633</td>
</tr>
<tr>
<td>Cost/ton</td>
<td>R8 01</td>
<td>R7 44</td>
<td>R6 31</td>
</tr>
<tr>
<td></td>
<td>100,00%</td>
<td>92,87%</td>
<td>78,76%</td>
</tr>
</tbody>
</table>

1. Final landform of spigot tailings dam
2. Landform for the cyclone dam
3. Landform for the paste tailings deposit
4. Comparative water losses per year over the life
All things considered, only the water make-up costs really make the difference. On a cost/ton basis the difference is only R1.70/t between the spigot and paste options. At the mine production rate of 115 000 tpm, this amounts to only R195 500/month or R2,35 million per year. Even for relatively small platinum mines, such an annual saving is not that significant, bringing into question the need for such optimisation.

The potential benefit of the paste, however, should not be judged solely on the limited annual saving since the water cost is likely to escalate over the life of the project. The paste option gives the mine the greatest protection against this potential escalation.

The spigot option theoretically consumes 0.55 m$^3$/t processed, whereas the paste option theoretically consumes only 0.28 m$^3$/t. So, for the same water licence quota, the mine could process nearly twice as much ore and benefit from the sale of the additionally recovered PGMs by adopting the paste option. The paste option is therefore far more environmentally responsible.

However, an unexpected obstacle arose in that the process design engineers argued that the reduction in make-up water could lead to salt build-up in the circuit, which could affect the process plant equilibrium and would not ‘guarantee’ the process. The owner was not prepared to take this risk and consequently elected to pursue the conventional spigot tailings disposal route.

CONCLUSIONS

The surprising results of the inclusive comparative study were:

- The total cost of tailings disposal for the mine is substantially more than just the construction and contractor’s operating cost.
- There is not really a significant difference in the cost of the different options over the life of the mine, and these are not sufficient to motivate deviating from proven technology.
- The differences occur mainly in the cost of make-up water and would hence be a function of the specific water balance of the mine and the make-up water unit cost.
- Paste emerged as the preferred option in this case for various reasons.

The first lesson learned from the comparative study is that the results were not a foregone conclusion and depended on the unique, relatively detailed, pre-feasibility design for each option. If optimal solutions are to be engineered, such comparative studies should be done at an early stage in the project.

Secondly, for new technology to be accepted, all affected parties need to be considered and supportive. In this case, the process design house was not part of the tailings solution and consequently resisted its acceptance. This emphasises the importance of including the tailings disposal in the early overall strategic planning of a mine.

The original paper on which this article is based, was presented at the 4th International Conference on Mining and Industrial Waste Management, held in Rustenburg from 11 – 12 March 2008.
Increasing emphasis on environmental protection at all stages of engineering projects

Many companies have become aware of the need for early environmental input, often beginning in a meaningful way at the pre-feasibility stage and continuing throughout the construction process. This has been the experience of SRK Consulting who are becoming more and more involved in projects from the outset, at the request of the client, in assessing environmental risks and identifying fatal flaws as opposed to simply conducting Environmental Impact Assessments (EIAs) for the purposes of obtaining environmental authorization, often once the detailed design stage of the project has been completed. At times, this involvement then continues throughout the construction phase. Two specific examples of this involve the world’s largest producer of cement, French-based Lafarge, and Petroline, a company planning the transportation of petroleum products from Matolo in Mozambique, to Kendal in Mpumalanga, with a view to connecting with an existing pipeline to Gauteng.

THE ROUTE TAKEN by Lafarge in the selection of a site for the construction of a cement grinding plant on the West Rand, goes well beyond legislative requirements. Six sites were identified by Lafarge, and then SRK was called in much earlier than would normally be the case so that they could be involved in a site selection process. Criteria taken into account resulted in Lafarge being able to meet market demand without compromising environmental standards. Of the six sites originally identified, the screening process undertaken by SRK resulted in the identification of environmental fatal flaws for three, avoiding the possibility of these sites being found to be fatally flawed only after a full environmental process had been initiated, hence a saving to the client from both a cost and programme perspective. In a similar exercise Petroline, while proceeding directly to the scoping and EIA phase of its proposed Matolo-Kendal pipeline, included several different
routes in the study undertaken by SRK, with equal weight being given to environmental and engineering considerations in the site selection process.

This approach provides both an indication of the culture of the organisation adopting it and of the current trend in South Africa and globally, with industry becoming conscious of its obligations in relation to the protection of the environment and the business risks involved in ignoring these obligations.

**CRADLE TO GRAVE**

The ideal of ‘cradle to Grave’ management of the environment may now be a step closer as a result of this trend. Lafarge has taken this philosophy to the next level and SRK continues to be involved in the West Rand Grinding Plant Project by providing the services of an Environmental Control Officer, required as a condition of the environmental approval for the project and ensuring that decisions taken in the EIA are implemented in construction. The same philosophy can now be implemented by Petroline, secure in the knowledge that environmental measures contained in the Environmental Management Plan for the project are based on environmental optimisation of the route selection in the first place. This included full public consultation at which all routes were presented and Petroline can rest assured of credible responses to any criticism of the final route selection.

While these two examples serve as an indication of a shifting corporate mindset, there are numerous other indications of the same trend. SRK is finding that it is not uncommon to be called in to participate in high level risk assessments prior to, or very early in, the development of an ELA. In this process environmental risks emerge, sometimes under different headings. For example water scarcity for mining operations may be identified by engineers as a risk, and even a potential fatal flaw, when the reason for the risk is environmental. It may be linked to the possible over-utilisation of an existing water source, an issue that would arise from an environmental study. Addressing this risk often becomes the responsibility of the environmental team, working in close association with the design engineers. Similarly, SRK has found that project developers are referring to the environmental team for the identification of sensitive landscapes and exclusion areas as part of their own site selection process.

It is clear that these trends reflect a rapidly increasing environmental awareness, but they do not negate the reality that sound environmental management, far from simply addressing an emotional and topical subject, also reflects good business sense. At least in the mining industry, SRK is finding that environmental management is increasingly being driven by the investment community in addition to the relevant environmental regulators. It is now a reality that, if you are serious about raising money for a project at an international scale, you also need to be serious about your environmental management. Several financial institutions, including Nedbank in South Africa, have become signatories to the Equator Principles, a set of guidelines introduced to establish an industry...
benchmark for determining, measuring and managing environmental risk in project financing.

The trend is now well established and SRK is in a position to assist companies such as Lafarge and Petroline, to ensure that their projects are in a position to benefit.
The City of Cape Town is developing the first integrated waste management facility in South Africa, comprising a refuse transfer station, a compaction hall, container handling operations, garden refuse chipping facilities, materials recovery facility, workshop, wash bay, diesel storage, domestic recycling centre and a public drop-off, security building, entrance building, weigh bridges, with provision for a future ‘resource park’ and accommodation for future ‘alternative technologies’.

Jeffares & Green, in joint venture with GIA Consulting Engineers, has been appointed to undertake the civil, mechanical and electrical design and implementation of the proposed Oostenberg Refuse Transfer Station and Materials Recovery Facility (ORTS and MRF).

The site is located in Kraaifontein, in the Cape Metropole, just off the N1 national road, and is approximately 15 ha with the ORTS portion of the site being approximately 3.5 ha, the balance being reserved for the future facilities.

The layout of the facility has been planned for a containerised bi-modal transport system (i.e. road and/or rail), although initially the transfer of containers will be done by road only. The rail infrastructure will be provided at a later date.

The design capacity currently allows for a 100 tonnes/day MRF (or 200 tonnes/day for a double 8-hour working shift) and a 1 000 tonnes/day refuse transfer station. It is not expected that these volumes will arrive at ORTS from the outset, as a host of factors come into play, for example the extent to which the City of Cape Town can manage the waste collections (i.e. routing/beats, vehicles, private contracts, and minimisation strategies) to take advantage of this facility. Tariffs and by-laws will also need to be examined and amended to promote the diversion of recyclable wastes.

The City of Cape Town’s Solid Waste Department will be the owner of the facility and it is currently envisaged that the function of the RTS and secondary facilities (workshop, wash bay, diesel tank, office block, control room/entrance building, security) will be operated by the City of Cape Town, whilst the MRF and drop-off will be operated by a private contractor.

Over and above the extensive engineering input into the design of this facility, the design team is spending time on ‘green engineering’ opportunities for this development, such as:

- rainwater harvesting, due to the extensive roof area
- supplementary supply of water harvesting by borehole or usage of clean storm water runoff from the site and/or from the existing municipal storm water pond across the road.
- low-energy lighting
- solar energy
- water-wise indigenous greening of the area
- specially designed oil traps
- site-specific litter traps and silt traps (a design that will be used by the City of Cape Town for research)
- maximising of natural ventilation opportunities
- maximising of natural lighting opportunities

**PROJECT STATUS**

Currently the estimated R160 million project is in the detailed design phase, preparing for the tendering stage. The team is aiming to be out to tender in August 2008 and to have the facility completed by early 2010.
De Hoop Dam brings hope

THE DE HOOP DAM is situated in the Limpopo Province, between the towns of Roossenekal and Steelpoort on the Steelpoort River, a tributary of the Olifants River which runs through the Kruger National Park on its way to the Masinger Dam in Mozambique. The construction of the De Hoop Dam not only brings hope of jobs and economic upliftment to the people of Sekhukhuneland and Limpopo, but also the prospect of permanent water supply to a dry land.

A screening exercise was done to investigate and identify the most suitable alternatives (dam and non-dam) for further development of the middle Olifants River catchment water resource. The dam alternative examined the potential social impacts in detail, and the non-dam alternative considered aspects such as water conservation, water demand management, ground water options and trading water allocations. The assessment of both the dam and non-dam alternatives contributed to a proposed project to facilitate greater water resource availability and stability in an area where the water demand surpasses the available water resources.

After the conceptual design and feasibility studies had been done it was concluded that the most feasible option from a technical, environmental and economical perspective would be the construction of a dam on the Steelpoort River, at the farm De Hoop, and associated infrastructure for bulk water distribution. The latter would include pipelines from a proposed abstraction weir near Steelpoort...
and from the Flag Boshielo Dam.

On 9 June 2004 Cabinet granted the Department of Water Affairs and Forestry (DWAF) approval for project implementation, subject to obtaining the necessary environmental authorisations. The National Water Act (Act 36 of 1998) states that in each area in the country there will be a number of possible solutions to balance water requirements with water availability.

**ORWRDP**

The De Hoop Dam will enable new allocation of water to meet the current and future water needs of the area, especially for the benefit of the mining sectors within the middle Olifants catchment, as well as part of the Mogalakwena and Sand catchments. DWAF commissioned the Olifants River Water Resources Development Project (ORWRDP), which comprises two phases:

- Phase 1 involved the raising of the Flag Boshielo Dam by 5 metres. This phase has been completed.
- Phase 2 involves the development of additional water resource infrastructure within the middle part of the Olifants Water Management Area. Phase 2A entails the construction of the De Hoop Dam and the realignment of the provincial road between Steelpoort and Stoffberg (the R555), whilst Phase 2B-2I involves the construction of pipelines and associated pumping stations and balancing dams.

Globally speaking, mitigating the detrimental ecological impacts of dams have by and large met with only a degree of success, as these impacts mostly are difficult or impossible to mitigate. For example, there is no realistic means of preventing the build-up of sediments in an impoundment of these dimensions, and nothing can be done about the riverine habitats that will become inundated. However, in an effort to ensure that the De Hoop Dam environment is protected and preserved as best possible, the environmental authorisation process was followed. Where applicable and appropriate, the requirements of the Environmental Conservation Act (Act 73 of 1989), the National Environmental Management Act (Act 107 of 1998), the National Heritage Resources Act (Act 25 of 1999), the Minerals and Petroleum Resources Development Act (Act 28 of 2002), the Forestry Act and the National Water Act (Act 36 of 1998) were adhered to.

An Environmental Impact Assessment (EIA) was undertaken to establish the potential impacts of the project on the socio-economic and biophysical aspects. The EIA comprised four phases, namely:

- Scoping
- Impact Assessment
- Environmental Impact Report
- Decision Making

International agreements were also considered, including Agenda 21, the Convention of Biological Diversity, the Kyoto Protocol, Helsinki Rules, and the SADC Protocol on Shared Waters. The UNEP Document on Dams and Development (Relevant Practices for Improved Decision Making), refers to the ORWRDP as an example of a large dam project where internationally agreed development goals are pursued in an effort to reduce poverty through environmentally and socially sustainable development of water resources. This is being done within the framework of DWAF’s sixteen principles of the guidelines for public participation, including consultation with stakeholders such as NGOs and interest groups, and stakeholder communication via an issues-and-response report and feedback process.

During scoping, as part of the EIA, six key issues were identified which needed to be further assessed and clarified, namely:

- impact on quantity and quality of river flows
- aquatic and terrestrial ecology
- long-term sustainability and water demand management
- capacity of the receiving environment
- minimising construction-related impacts
- land acquisition and compensation

It was also broadly agreed that a seventh issue, cooperative governance, needed consideration for future planning and implementation of Phase 2.

The De Hoop Dam study area is an ecologically sensitive region and required extensive environmental investigations before a Record of Decision (ROD) was issued by the Department of Environmental Affairs and Tourism on 21 November 2005. This was followed by five appeals against the decision which had to be investigated and responded to by DWAF, before the Minister of the Department of Environmental Affairs and Tourism on 16 October 2006 made a final decision in terms of Section 35 of the Environmental Conservation Act (Act 73 of 1989) – that is, the revised Record of Decision – in support of the project, but incorporating more stringent environmental requirements.

This revised ROD has many conditions of authorisation which DWAF has to comply with to minimise the potential impacts as anticipated by the appeals, including a suite of Environmental Management Plans (EMPs) to be prepared, namely:

- Pre-construction EMP
- Construction EMPS (7 different EMPS)
- Post-construction EMP
- Operational EMP

In compliance with the requirements of the revised ROD, the ACC (Authorities Coordinating Committee) and the EMC (Environmental Monitoring Committee) have been established. There is also a full-time Environmental Control Officer (ECO) on site, as required by the ROD.

On 19 March 2007, during a sod-turning event, the project was launched at Maseven. Prior to the commencement of construction, the De Hoop Dam Charter was also signed, containing the social and economic development and procurement targets of Government. The 347 million m³ of water will be impounded by an 88 m high roller-compact concrete wall.

On 26 May 2008 a Memorandum of Agreement (MOA) was signed between the Minister of Water Affairs and Forestry, Mrs Lindiwe Hendricks, twenty-three individual mining houses, and the Joint Water Forum (JWF), a representative body of associated mines involved in exploiting the mineral resources of the Eastern Bushveld Complex in the southern part of the Limpopo Province. This MOA paved the way for R74 billion of water supply to Limpopo. It essentially encapsulates the principles to be distilled in the individual off-take agreements with the mines and is the founding agreement for the implementation of the ORWRDP for the needs of the mining users located in the project area.

The Trans-Caledon Tunnel Authority (TCTA) was requested to develop a financing proposal for the project, subject to the approval of DWAF and the National Treasury. It has been Government policy since 1997 that all commercially viable projects have to be funded off-budget by making use of private sector funds with loan repayments from the revenue of the
water tariffs. The off-take agreements with the mines will provide the necessary channel for private sector funding required for project implementation.

As there are two main end users in the project – the mines and the social users – DWAF, in consultation with the TCTA, negotiated the MOA with various mining institutions represented by the JWF, in terms of which the mines commit to taking all their future water requirements, specific to the project area, from the project. The MOA also enables the mines to continue with their mining license applications.

In terms of the MOA, Government will fund the social users’ portion of the infrastructure, which will be recorded in off-take agreements with the relevant municipalities. The tariff structure will vary for the two end users in that the commercial users will pay a Capital Unit Charge (CUC) whereas the municipalities will pay a Return on Asset (ROA) charge on the capital investment.

Other users include ESKOM (for their proposed pumped storage scheme) and a host of water supply authorities who will be responsible for the treatment and distribution of water to the domestic sector.

In an effort to keep to the social and economic upliftment objectives of the project, the Charter requires that the contractors recruit 60% of the labour locally. This labour may be recruited from three local areas in prescribed percentages, and preference is given to women and people with disabilities. The contractors should also provide generic and entrepreneurial training so as to leave behind a workforce with enhanced skills.

Construction on the project started in June 2007.

The geology of the area includes the mineral-rich Bushveld Igneous Complex. Mining activity is rapidly expanding, requiring water and power. At the same time, approximately 800 000 people are residing in the near vicinity, without recourse to a safe and reliable water supply. Government hence views the early completion of the dam as of major importance.
NATIONAL CONSERVATION FOREST

According to the specialist vegetation study reports on the project area, 295 plant species were recorded in the proposed dam basin, of which nineteen are highly sought after and widely used in the Steelpoort Valley as medicine, for food and firewood, and in traditional customs. Of these species, four are in such high demand that they are now considered endemic or near-endemic by the Sekhukhune Centre of Plant Endemism (SCPE), and one is a Red Data species.

Measures were introduced to ensure the protection of the fauna and flora in the project area for future generations. Accordingly, before the commencement of construction work SANBI (South African National Biodiversity Institute) carried out the identification and removal of endangered plants in the prioritised areas. The flora was moved to the National Botanical Gardens in Pretoria, and some unique seeds were sent to the Millennium Bank in Kew Gardens, London. The SCPE plants were used in the landscaping of the De Hoop Dam Information Centre, and the Boscia Albitrunca (Shepherd’s Tree) was transplanted from the dam basin area to the garden of the Information Centre. The Information Centre will provide the community and visitors with information on dam development activities and water resource management, as well as on the cultural (archaeological) and natural heritage aspects of the project area.

The project area was approved as an off-site mitigation area, and was consequently declared a National Conservation Forest. It was gazetted as such on 6 July 2007 under the National Forest Act. This land is now protected under state law, and no wood harvesting, or any other type of harvesting, is allowed. The protection of plant species (near-endemic, endemic and common) benefits not only Sekhukhuneland and its inhabitants, but also the greater region, as it preserves a unique floristic area for future generations. The sustainability of these initiatives will greatly depend on the cooperation of locals and visitors.

ARCHAEOLOGICAL SITES

During the Heritage Impact Assessment, the presence of a large number of iron-age sites was recorded. One of the requirements of the ROD was that these archaeological sites would be researched and recorded before construction work could advance. This work is well advanced under the leadership of Professor Johnny van Schalkwyk, with the research team painstakingly digging, trowels and brushes at hand, uncovering secrets of the past. A substantial number of graves had to be relocated – 118 of the 209 on the register were relocated after consultation with the affected families.

PROGRESS

The housing and site services contracts, as well as the P169-1 road realignment, are continuing and some contracts are nearing completion. The pouring of concrete for the dam has already started, while work on the right flank of the excavation is progressing.

The design of phase 2B, 2C, 2D, 2H and 2I (the bulk distribution system) will commence off-budget via the funding obtained by the TCTA from the private sector. However, the scale and scope of construction will depend on the number of off-take agreements signed. Discussions with the JWJ, ESKOM and the Water Services Authorities will continue in all earnest in order to conclude the above-mentioned off-take agreements.

DWAF is committed to appropriate international best practice and, in line with this aim, external review panels were appointed to both the technical and the environmental suite relating to the dam. As the ECO is also monitoring and reporting on the social and environmental impacts of the project, a holistic assessment of both negative and positive impacts on society and the natural environment will take place by ensuring this process continues after project completion. These study results will shape the project’s future operation and maintenance plan to minimise any possible negative impacts.

Acknowledgement

Published with permission from the Director-General of the Department of Water Affairs and Forestry.
THANKS TO THE expertise Degrémont has acquired through its works with existing installations, the company’s water treatment engineers are able to propose effective solutions for aging installations, including the following:

- Ascertaining which treatment processes should be instituted
- Optimization of operating and constraint-related costs
- Rebuilding and upgrading existing installation processes, while still retaining as many existing structures as possible and keeping construction engineering costs to a minimum

Degrémont has built more than 1000 water treatment plants in Africa and 120 plants in South Africa and therefore have many requests for rehabilitation in this country.

To cite a few plants, which have been recently rehabilitated in Africa:

1 in Niger, 2 in the Democratic Congo, 3 in Tanzania and 3 being upgraded for the moment in Nigeria.

Degrémont South Africa can assist the client with a complete assessment for the refurbishment of water treatment plants, spares supply, support and training for operation optimization.

Degrémont’s various technologies can be proposed, depending on client requirements and site constraints: compact units, such as lamellar modules or membrane technology to optimize the performance, or conventional treatment to reduce costs, this either in drinking water treatment or waste water.

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THE GAUTRAIN TUNNEL Boring Machine (TBM) is a colossal moving factory that is boring a 3 km section of tunnel from Rosebank Station southwards, while at the same time lining the tunnel behind it with pre-cast concrete segments that are installed within the protection of the tail shield of the TBM.

The inner diameter of the 3 km tunnel is 5.86 m and the outer diameter 6.46 m, giving a thickness of 300 mm to the tunnel segmental lining. All elementary rings are identical and 1.5 m long, measured along the axis of the tunnel, with each ring consisting of 6 segments, namely:
- 3 standard segments (S1, S2, S3)
- 2 counter-key segments (S4, S5)
- 1 key segment (S6)

To navigate curves the segmental rings are tapered. This allows for the geometric control of the general alignment with a theoretical radius of 750 m, by rotating the rings relative to each other. The segment length along the tunnel axis varies between 1.49 m at the key segment and 1.51 m at the directly opposite standard segment, S1.

To ensure a watertight tunnel lining, a compressive gasket is installed around the whole perimeter of each segment, in a specially formed rebate. In order to temporarily stabilise the segmental ring, temporary bolts are used to connect the newly installed segments with the previously erected ring. The segments incorporate box-outs and built-in plastic sockets to facilitate bolt installation. Segments are installed using a vacuum lifting device situated in the tail of the TBM.

The gap between the extrados of the ring and the soil is filled by mortar injected through the tail shield to form an intimate contact between the tunnel lining and the ground to limit settlement and ensure even load distribution on the tunnel ring.

DESIGN CRITERIA
The segment reinforcement design is based on maximum ring loads, allowing the use of identical rings throughout the whole bored tunnel length. The reinforcement design is based on two loading conditions, the first being the construction phase, catering for loads from the manufacturing to the final placing of the segments within the TBM, including the forces exerted by the thrust-jacks when the TBM is advancing (4 000 t). The second load case is the permanent phase, with allowance for all loads created by the geological ground conditions and by live loads during operation.

Since much of the tunnel is located beneath the ground water table, a stringent quality control system is being implemented to assure the water tightness of the final tunnel lining.

PRE-CAST FACTORY
The pre-cast concrete segments are manufactured by Southern Pipeline Contractors (SPC), at a factory located approximately 25 km east of Johannesburg. Concrete is produced at the factory owned batching plant with a production capacity of 18 m³ per hour. Forty-two
sets of segment formwork (constituting 7 rings with 6 segments each) have been supplied by the French tunnel engineering group CBE, a world leader in the highly specialised market of steel moulds for tunnel concrete segments. Each mould is equipped with pneumatic vibrators and is required to produce concrete segments to the very tight tolerances of +/-1.0 mm. The dimensional tolerances of the moulds themselves are +/- 0.3 mm and these are checked regularly with appropriate templates.

CBE also supplied parts for the mould evacuation line, such as two vacuum lifting devices hooked to the factory’s gantry cranes to extract the segments from the moulds and transport them inside the factory, the segment rotation machine to turn the segments around from the production position to storage position, and the gasket bonding frame which applies pressure on the gasket after it has been glued into the purpose-formed recess in the segment. The completed segments are then lifted by locally manufactured grabs and transported to the factory’s storage area.

**PRODUCTION CYCLE**

The production cycle commences with the preparation of the 42 moulds, including cleaning (removal of concrete, dust and other residue from previously produced segment casting), assembly of moulds (including periodic checking of tolerances), and application of release agent to the surface of the moulds. Completion of preparation requires acceptance by a quality controller before proceeding further.

The pre-assembled reinforcement cages (welded on specialised jigs) are placed with spacers fixed at defined positions. The cover to the reinforcement is checked by quality control. Cast-in items, such as bolt sockets, are installed before the pre-concreting final check and closure of mould.

Concrete is manufactured on site at the factory by an accredited batching plant according to an approved mix design. Slump tests are performed on every batch before casting of segments. Overhead concrete skips pour concrete into the steel shutters whilst vibrating the moulds, but in order to prevent segregation, vibration is not permitted to exceed 300 seconds per mould per pour.

Fifteen minutes after the concrete has been placed and compacted, the cover of the mould is opened to allow concrete surface finishing and application of an approved curing compound to the extrados. To prevent dehydration of the fresh concrete the opened mould is covered with a tarpaulin.

1. Placement of pre-assembled reinforcement cages onto steel moulds for the manufacturing of concrete tunnel lining segments
2. Tunnel lining segments in the pre-cast factory
3. Tunnel lining segments stacked, ready for transportation to the TBM site
4. Tunnel lining segments on site, ready for transportation to the TBM point of installation inside the tunnel
Twenty-four hours after casting, and provided that an early-age strength of 15 MPa has been reached, demoulding of segments takes place. After the sides of the moulds have been removed the segment is vertically removed out of the mould with a vacuum lifting device, suspended from a gantry crane, and transported to a temporary storage area for quality checking, which includes inspection of the gasket recess, minimum cover of reinforcement, and extrados surface finishing. At this stage, necessary, permissible concrete repairs are carried out, according to approved segment repair methods and each segment receives an individual identification mark which relates to its production history.

For storage, handling and transport reasons the segments are rotated 180° by a segment rotation machine. Once the segments have been rotated so that the intrados surface is face up, the segment is lowered onto the transfer trolley and moved to the next production station where gasket fixing takes place. Before the gasket and guiding rods are placed, the purpose-formed rebates are dusted and glue is applied using an airless spray gun. The guiding rods are fixed to each segment so that they will mate with the corresponding receiving recesses of the adjacent segment in the ring, thus assisting the accurate placement of segments inside the tunnel. After placing the neoprene gasket, the gasket press is lowered and pressure applied to achieve proper bonding.

The next station in the production line applies curing compound onto the exposed concrete surface of the segment before the segment is transported to the temporary storage area and a further quality control check is undertaken.

Although the factory is equipped with 42 moulds, such that 42 segments can be cast simultaneously, the factory possesses one evacuation line which is the ‘bottle neck’ of the production cycle. The production cycle is designed for a production output of one segment every 10 minutes at the bottle neck, thereby achieving 42 segments per working day. The total period of production planned for the 12,000 segments is approximately 15 months.

MATERIALS
Concrete
In order to achieve the production of one segment per mould per 24 hour cycle the segments require an early-age strength of at least 15 MPa after 20 hours. The segments are required to have a compressive cube strength (150 mm x 150 mm) of at least 50 MPa at 28 days. Before erection in the tunnel, the concrete segment strength requirement is 55 MPa. Therefore, three extra test cubes are cast for each batch of segments and tested at 56 days to check that the compressive strength has reached 55 MPa.

The concrete mix consists of Cement CEM I 42,5 N (350 kg/m³), blastfurnace slag (100 kg/m³), fly ash (100 kg/m³), aggregates (19.0 mm max size), water and plasticiser. Workability calls for 60 mm slump concrete and the maximum water/cement ratio is set at 0.45.

Reinforcement
The segments include 82.5 kg of steel rebar per m³ with the reinforcement being accurately assembled by means of specialised jigs. The minimum concrete cover to the reinforcement is 30 mm.

QUANTITIES
The 3 km long tunnel will be lined with 1,000 segments, consisting of 17,420 m³ of concrete and 1,437 t of reinforcement steel. The reinforced concrete volume of one ring is 8.71 m³, one standard or counter key segment comprising 1,585 m³ of concrete weighing 41 t (concrete density 2,55 t/m³), and one key element comprising 0.787 m³ of concrete weighing 2 t.

STORAGE, TRANSPORT & INSTALLATION
Four thousand segments can be stored at SPC’s factory at any one time and 50 rings (300 segments) can be stored on site next to the tunnel portal. The segments are transported from the pre-cast factory to the tunnel site on normal road trailers (one ring of six segments per trailer). From the site storage area the segments are lowered into the shaft by a tower crane and transported to the TBM, stacked in pairs on rail wagons, from where they are forwarded to the point of installation on a segment feeder and installed by the TBM’s vacuum segment erecter. The excavation production is planned on an average rate of 10 m advance per day, i.e. 7 rings.

CHALLENGES
The greatest challenges relate to developing the necessary standards of workmanship and quality assurance to match the specification requirements. This has been successfully achieved by breaking down the production cycle into manageable elements under the control of designated supervisors and implementing strict quality control procedures at each stage in the process. The resultant quality of the product is self evident.
THE CONSTRUCTION of the Berg River Dam entered its final phase with the successful release of 200 m³/s. On 12 June 2008, 1.4 Mm³ of water was released in the build-up to the 200 m³/s designed capacity of the 5.5 m diameter conduit conveying the water from the intake tower through the dam wall to the outlet works. This flow is equivalent to a natural 1:2 year flood event.

The 3.4 m by 2.9 m flood release (radial) gate housed in the outlet works was fully opened to release the large volume of water under gravity and a head of 31 m in order to test the 3.8 m by 3.2 m emergency (bonneted sluice) gate housed in the intake tower. The emergency gate was driven down by power supplied by a standby generator. Thus, a full emergency situation was simulated and successfully tested.

The Berg River Dam is a concrete-face rockfill dam with a gross storage capacity of 130 Mm³. The dam wall is 62.5 m high, 990 m wide and 220 m in width at its base. Currently the dam is 52% full and with average rainfall this winter season it should fill to 100%. The outlet works have been designed to release both low and high flows with provision for a peak release of up to 200 m³/s.

In terms of the National Water Act of 1998, there is a requirement for the provision of water of a suitable quantity and quality to be released into the watercourse or river below a dam or other works to provide for basic human needs or to protect the aquatic ecosystem. This requirement is known as the ecological reserve and is the right in law.

The Berg River Dam has been designed to cater for low and large volume releases. The system for low releases occurs in the range of 0.3 m³/s to 12 m³/s. These releases occur continually and are adjusted in magnitudes as required by the ecological reserve and depending on the inflow into the dam.

The other part of the outlet works which houses the flood release gate is able to control large releases of up to 200 m³/s. These large flow releases will mimic naturally occurring flood events.

During the large volume release, the Emergency Preparedness Plan was implemented and tested by the well organised disaster management centre of the Cape Winelands District Municipality in conjunction with the Stellenbosch and Drakenstein municipalities. With emergency services posted strategically along the riparian area extending from the Berg River Dam to the town of Paarl, the general public was informed regarding the development of a potential hazardous situation downstream of the dam after implementing early warning procedures and evacuation procedures.

The dam forms part of the R1.6 billion Berg Water Project and supplies water to the Western Cape Water Supply System.
The Berg Water Project

supplement scheme

AS THE FIRST LARGE water resources infrastructure development project in South Africa to be designed, constructed and operated within the framework of the National Water Act and in accordance with the guidelines of the World Commission on Dams, a brief overview is given of the Berg Water Project (BWP), with special focus on the Supplement Scheme as part of the broader BWP.

ORIENTATION

The Berg River Dam, Dasbos pump station and pipeline to Dasbos tunnel and adit are situated approximately 6 km northwest of Franschhoek in the Berg River Valley.

The Drakenstein abstraction works and pump station are situated approximately 10 km downstream of the dam site on the right bank of the Berg River on the grounds of Drakenstein Correctional Services, and 1.5 km west of the R301 to Paarl.

The operations offices and control room for the project are situated in the Dasbos pump station, which is on the left bank of the river, approximately 200 m downstream of the dam.

BACKGROUND

In response to the increasing demand for water in the Greater Cape Town region, DWAF initiated the Western Cape System Analysis in April 1989. The BWP, which included inter alia the Berg River Dam (previously known as Skuifraam Dam) and Supplement Scheme, was identified as the preferred new water scheme to augment the water supplies from the Western Cape Water System.

The upper catchment of the Berg River to the south of the dam site is one of the most productive water catchments in the country and the BWP harnesses this resource for the benefit of the water users in the urban and agricultural sectors of the Western Cape. The BWP augments the yield of the Western Cape Water System by 81 Mm$^3$ (to 523 Mm$^3$) per year and integrates with the Riviersonderend – Berg River Government Water Scheme.

The project was funded and implemented by Trans Caledon Tunnel Authority (TCTA).

Berg River Consultants, a joint venture between Knight Piésold Consulting, Goba Consulting Engineers and Project Managers, and Ninham Shand Consulting Engineers, were appointed by TCTA in December 2002 as design and construction supervising consultants.

Impounding of the dam started in July 2007 and the pump stations and interconnecting pipework were brought into operation during the middle of 2008.

On completion of construction, the project components will be owned by TCTA, but operated and maintained by DWAF as part of the Western Cape Water System.

GENERAL DESCRIPTION AND MAIN COMPONENTS

In broad terms the components of the BWP are:

- The Berg River Dam on the upper Berg River in the La Motte forest. The dam is a concrete-faced rockfill dam (CFRD) approximately 938 m in length and 62.5 m high. The appurtenant structures include a 65 m high intake tower, a 5.5 m diameter concrete outlet conduit, outlet works and an ungated side channel spillway. The reservoir has a volume of 130 million m$^3$ and a surface area of 537 ha at FSL. The dam provides an additional 56 Mm$^3$/a of water to the Greater Cape Town region.

- A pump station (the Dasbos pump station) and a 2.5 km long 1.5 m diameter (Dasbos) pipeline to convey water from the dam to the Dasbos adit of the Riviersonderend Tunnel System and thence into the Western Cape Water System – referred to as the Dasbos System. The system is designed to deliver 3 m$^3$/s initially, with the option of increasing to 6 m$^3$/s in future.

- Abstraction works on the Berg River below the Dwars River confluence consisting of a low diversion weir, boulder, gravel and sand sediment traps, a covered diversion canal, a balancing dam and a pump station (the Drakenstein pump station). The water is pumped via a 10 km 1.5 m diameter
(Drakenstein) pipeline to the dam and connected to the pipework at the Dasbos pump station – referred to as the Drakenstein System. The system is designed to extract excess winter water from the Berg River below the confluences of the Franschhoek, Wemmershoek and Dwars rivers and pump it back to the dam for storage, thus supplementing the water stored (25 Mm³/a) in the dam.


**OPERATING PARAMETERS AND DESIGN PHILOSOPHY**

In summarised terms the BWP has been designed to fulfil the following operational requirements:

- Flood releases of up to 160 m³/s through the wet well in the intake tower and the conduit to maintain the ecological status of the Berg River downstream of the dam (the system is capable of releases of up to 200 m³/s).
- Monthly environmental in-stream flow requirement (IFR) of between 0,36 m³/s and 8,6 m³/s released through the sleeve valves at the outlet works.
- Draw-off of up to 3 m³/s (increasing to 6 m³/s in the future) from the dam through the pipes in the dry well in the intake tower and pumped through the Dasbos System into the Riviersonderend Tunnel System and Theewaterskloof Dam.
- Future requirement to feed directly to the proposed Muldersvlei Water Treatment Plant by means of gravity or the Dasbos pump station.
- Abstraction of up to 4 m³/s from the Berg River at Drakenstein Correctional Services in winter and pumped through the Drakenstein System and the dry well piping in the intake tower to discharge into the dam to supplement storage in the dam.
- Releases of up to 6,7 m³/s from the Berg River Dam, or preferably Theewaterskloof Dam, via the Riviersonderend Tunnel System into the Berg River at the confluence of the Wemmershoek River for irrigation purposes in summer.

These operational requirements have set a challenge for the designers to economically integrate the requirements with the infrastructure designed and constructed as part of the project.

**SUPPLEMENT SCHEME**

The Dasbos System is required to transfer water from the Berg River Dam to the Riviersonderend Tunnel System. Furthermore,
it was recognised that by constructing a diversion weir downstream of the dam at Drakenstein, surplus water from the Franschhoek, Dwars and Wemmershoek rivers could be pumped to the dam to supplement yield of the scheme.

**Dasbos System**

**Dasbos pump station**

The pump station has a reinforced concrete substructure (pump well) and a superstructure of reinforced concrete columns and beams, with plastered and painted brick infill wall panels. The pump units are positioned in the pump well on concrete plinths. Provision has been made for five pump sets, but only four sets have been installed. The fifth set can be installed when and if water demand increases beyond present capacity.

Operating staff offices and facilities as well as the project control room overlooking the outlet works of the Berg River Dam are housed in the pump station building.

Four Sulzer SM 501-640/imp 635 mm single-stage horizontal centrifugal split casing pumps with 3.01 MW ALSTOM motors and controlled by ABB variable speed drives capable of delivering 3 m$^3$/s now and 6 m$^3$/s in future, with the installation of a fifth set at 135 m head, are installed. Transformers and switchgear were manufactured by ABB and ALSTOM respectively. The suction and delivery manifolds are situated underground outside the building.

The suction manifold draws water from one of five bell mouth intakes from five levels and either one of two pipe stacks in the dam intake tower and by way of cross-connected pipework south of the pump station. The Drakenstein pipeline is situated to the east of the pump station and is connected directly to one of the pipelines and pipe stacks or via the cross connection to the alternative pipeline and pipe stack in the intake tower. The delivery manifold is connected to the Dasbos pipeline.

The Dasbos – Drakenstein cross connection connects the Dasbos pipeline and the Drakenstein pipeline to the north of the Dasbos pump station.

The Dasbos pump station bypass pipeline is provided to feed water directly by gravity to the future Muldersvlei Water Treatment Works (WTW) bypassing the pump station when the water level in the dam is sufficiently high to allow this.

**Dasbos pipeline**

This pipeline serves three functions:

- To transfer water from the Berg River Dam to the Riviersonderend Tunnel System
- To transfer irrigation water from Theewaterskloof Dam to the Wemmershoek Irrigation Release Works (via the Drakenstein pipeline)
- To transfer water from the Berg River Dam to the future Muldersvlei WTW

The pipeline to the west of and from Dasbos pump station to the Dasbos adit and tunnel follows a gradually rising route around the toe of a mountain above the left bank of the Berg River. The pipeline connects the Dasbos pump station with the Dasbos tunnel and adit, which links up with the Riviersonderend Tunnel System. The latter conveys raw water from Theewaterskloof Dam via Kleinplaas Dam, situated in the Jonkershoek valley above Stellenbosch, to the Faure and Blackheath Water Treatment plants. This tunnel system was constructed at the same time as the Theewaterskloof Dam, in the mid 1970s.
Just before entering the Dasbos tunnel the pipeline passes through a chamber, in which an isolating valve is installed. At the chamber exit a sweep tee turns the pipeline into the tunnel. In view of a possible future connection to the Muldersvlei WTW a Y-branch has been installed just beyond the sweep tee, with a second sweep tee back towards the chamber, all with isolation valve and blank flange for later connection to the proposed Muldersvlei pipeline.

The Dasbos pipeline has a cross connection to the Drakenstein pipeline just north of Dasbos pump station to:
- divert water from the Theewaterskloof Dam via the Dasbos tunnel and Drakenstein pipeline to the Wemmershoek Irrigation Release Works during the summer months
- gravitate water from the Berg River Dam past the Dasbos pump station to the future Muldersvlei Water Treatment Works

**Dasbos tunnel and adit**
The pipeline connects to the Riviersonderend Tunnel System (RTS) about 200 m into the adit.

Inside the Dasbos adit and up to a domed bulkhead the pipeline is mounted on concrete pedestals, offset to the right with a sufficient clearance between the pipe pedestals and the left tunnel wall to allow vehicular access down the adit and through the dome (when opened) into the tunnel.

The connection to the concrete lined tunnel is by means of DN2500 3CR12 strake fully concrete and grouted into the tunnel with a hinged dome on the end to allow vehicular access to the tunnel. From this strake a bifurcation and DN1500 valve connects to the Dasbos pipeline. For safety reasons a further isolating valve has been installed inside the tunnel in close proximity of the access dome. The design of the connection to the RTS took into account minimal downtime and disruption of water supply from Cape Town’s main water source, the Theewaterskloof Dam. The dewatering of the Riviersonderend Tunnel System and connection to the existing bulkhead was achieved in nine days – the physical connection / tie-in taking just two days.

**Drakenstein System**
The Drakenstein System’s primary function is to abstract surplus water from the Berg River during the winter months and pump it to the Berg River Dam to supplement the yield of the dam.

During the summer months the Drakenstein pipeline will be utilised in reverse mode to convey irrigation water from the Theewaterskloof Dam (via the Dasbos pipeline) or Berg River Dam to the Wemmershoek Irrigation Release Works, situated on the Wemmershoek Dam, immediately upstream of the confluence with the Berg River.

The Drakenstein System of the Supplement Scheme consists of the following elements:
- Drakenstein abstraction works on the Berg River consisting of:
  - Diversion weir with canoe chute and fish ladder
  - Diversion works including boulder, gravel and sand traps and associated stop logs, gates and sluices
  - Diversion canal to the balancing dam with inlet control gate
  - Balancing dam
  - Drakenstein pump station
  - Drakenstein pipeline from Drakenstein pump station to the Berg River Dam

**Drakenstein abstraction works**
The diversion weir has an ogee crest and roller bucket energy dissipater to prevent downstream erosion. This type of weir has the advantage that it effectively reduces erosion downstream by creating an opposite flow direction at bottom level. The structure is positioned perpendicular to the anticipated flow direction during high floods and has an overflow length of 65,25 m. The total width of the weir, in the direction of flow, inclusive of the roller bucket, is 12,53 m. The weir has a flat bottom, and is supported in the cobble/boulder strata, about 4 m below natural river bed level. Its underside is linked to an engineered cut-off through the cobble/boulder strata down to a low-strength base rock. The cut-off consists of a pressure-grouted 1,5 m wide strip and is intended to prevent piping and essentially reduce seepage below the weir to a minimum. The river bed downstream of the weir is protected against erosion by means of rip-rap, with a D50 size of 1,1 m sourced some 60 km from site and almost delivered one by one to site! The rip-rap was placed on a filter layer of smaller size rip-rap.

The left-hand non-overflow section of the weir has a flank wall rising to level above the calculated level of a 1:100 year flood at this point.

On the right-hand side of the weir a canoe chute and fish ladder have been incorporated in the weir/ diversion structure. Water flows uncontrolled firstly through the fish ladder and then through the canoe chute fulfilling the river instream flow requirements (IFR) of up to 1,5 m³/s during the drier summer months. The adopted average minimum and maximum monthly IFRs in winter vary between 1,5 m³/s and 2,86 m³/s.

At full supply level (FSL) the combined flow through canoe chute and fish ladder would be about 1,5 m³/s. At higher IFRs the boulder trap gate will be opened to provide additional capacity.

Of the various fish ladder designs available the one chosen is considered the most suitable for fish found in the Berg River. It is provided with vertical slots in the baffle walls, placed in one line near one side, thereby creating sheltered small pools at each step for the migrating fish.

Downstream of the canoe chute a pool has been created, which basically consists of a deepening of the rip-rap protection. In addition, the rip-rap has been grouted in this location for the protection of canoeists and canoes.

Embankments protected by rip-rap have been constructed on the left and right banks to contain the river during floods of up to a 1:50 year event and to prevent the river scouring a new channel and thus bypassing the diversion works during 1:100 year flood conditions. The left hand embankment extends upstream to the confluence of the Dwars River. It is provided with a drainage system alongside the toe of the embankment on the landward side in order to control the ground water level in an adjacent vineyard and for releasing storm water to a point downstream of the diversion weir. It also functions as a draining devise after flooding. The embankment connects onto the non-overflow section of the weir on the left bank.

The right-hand embankment extends for a similar distance upstream of the diversion works, but excludes a draining system along the landward side. The right-hand embankment butts up against the extended wall of the gravel/boulder traps and has been built to generally the same levels as the left-hand embankment.

The diversion works are situated on the right bank and bend of the Berg River following investigations into the course of the river bed.
river over 60 years. The works are designed to divert water from the river into the works, remove sediment down to a particle size of 0.4 mm and divert the water to the balancing dam via an underground diversion canal. The diversion works, diversion canal, balancing dam and pump station are all located in the 1:200 year flood plain of the Berg River, which is 300 mm higher than the 1:50 year flood level, and was the subject of a model study at the University of Stellenbosch to ensure minimal river flow obstruction in the floodplain.

The sediment removal structures consist of boulder, gravel and sand traps and have been configured on the basis of model studies of the whole diversion works complex. These structures are designed to divert a maximum of 6 m$^3$/s of river water. The boulder, gravel and sand traps remove sediment down to 40 mm, 2 mm and 0.4 mm in size respectively. A key emphasis in the design was to make the structure self-cleaning, using gravity flow washing sediment back into the river. This maintains the sediment load and river ecology and negates the necessity for costly removal of sediment from sediment traps.

Boulder scour (radial) and gravel scour (radial) gates, situated in the flushing channels downstream of the boulder and gravel traps, are used in the periodic controlled discharge of river water to flush out the boulder and gravel accumulations. The sand traps, of which four have been provided, can be flushed individually by means of sliding (sluice) gates. Trash racks are installed on the trailing wall upstream of the sand traps.

A sand scour (radial) gate positioned downstream of the sand traps is opened during flushing of one of the sand traps, allowing the flow plus sediment to be diverted back to the river downstream of the weir.

A 4.0 m wide by 2.5 m high roofed concrete diversion canal discharges the cleared water from the diversion works into the balancing dam. The flow through the diversion canal is regulated by means of an automated diversion (sluice) gate, which is controlled via a combination of signals from instruments placed in three locations. A level monitor in the river, upstream of the weir, triggers the opening or closing of the diversion (sluice) and boulder and gravel (radial) gate by comparing actual river level with the level at IFR and diverted flow. An ultrasonic flow meter, working in conjunction with a parshall flume inside the diversion canal, as well as a level monitor in the balancing dam, provides further control signals.

Abstraction starts when the IFR is exceeded, by opening the diversion (sluice) gate, which will allow water to enter the diversion canal up to a maximum of 6 m$^3$/s. Above IFR + 6 m$^3$/s the boulder scour gate opens further, followed by the opening of the gravel scour gate. These two gates will close in reverse sequence when the flow subsides again. The purpose of these operations is to maintain the FSL upstream of the weir as long as possible to maximise river abstraction. Overflow of the weir will thus only occur when river flow exceeds IFR + 6 m$^3$/s + capacity of boulder and gravel trap (radial) gates.

The diversion canal discharges the flow through six 1.0 m wide by 0.6 m high openings, placed at the invert of the canal, into the balancing dam. These six openings are strategically spaced to obtain even flow into the balancing dam.

The balancing dam optimises water storage for pumping purposes and to allow settlement of fine sediment up to 0.2 mm in size. Its crest level dimensions are approximately 360 m x 123 m. Embankments with rip-rap protect the balancing dam from floods up to a 1:200 year event. Generally the sides below FSL and
10 m rim of the bottom of the dam are lined with Armourflex to keep the shape of the dam. As the FSL of the dam is below the natural groundwater level, loss of water is not a concern.

Plant access into the diversion canal and the balancing dam itself for clean-out purposes is obtained by means of a ramp at the northeast side of the balancing dam. Clean-out operations could take place during the summer months once the sediment reaches a predetermined level immediately upstream of the pump station pump intakes.

**Drakenstein pump station**

This pump station pumps water from the balancing dam through the Drakenstein pipeline to the Berg River Dam.

The pump station structure consists of a substructure of four separate concrete sumps and a superstructure of reinforced concrete columns and beams, with plastered and painted brick infill panels. The electrical motors, screens loading bay, storage area, operators’ facilities, switch room and transformer bays are situated at ground floor level above the 1:200 year flood level.

Flow into the sumps passes through trash racks. These are cleaned by manual intervention. The sumps of the pump station, inclusive of the secondary concrete, guide vanes and inlet configuration below the pump intakes were analysed with CFD (Computerised Fluid Dynamics) software to ensure proper operation in order to prevent vortex formation, pre-rotation and swirling.

Four Sulzer BK 850 3-stage vertical spindle turbine pumps driven by 2,67 MW ALSTOM motors and capable of delivering 4 m\(^3\)/s at 145 m head are installed (three in operation, one standby). Soft starters, transformers and switchgear were manufactured by Allan Bradley, ABB and ALSTOM respectively.

An external delivery manifold with isolating valve joins onto the Drakenstein pipeline.

**Drakenstein pipeline**

The pipeline from the Drakenstein pump station to the Berg River Dam (the Drakenstein pipeline) follows a route generally parallel to the Berg River but outside the 1:100 year flood line at varying distances of up to 600 m from it. The pipeline crosses several services, such as the Wemmershoek potable water pipeline and the R45. It also crosses the Wemmershoek and Berg rivers. This presented various construction challenges to the contractors as the Berg River pipeline crossing immediately upstream of the R45 bridge crossing is 6 m below natural riverbed level.

The selection of the route was a lengthy procedure and determined on the basis of topographical surveys, the 1:100 year flood lines, and land owner input. Geological investigations were undertaken and the results used in the final stages of the selection process.

The vertical alignment of the pipeline has a minimum slope of 0,35% for drainage purposes. A maximum negative slope of 21% has been adopted for the effective removal/transportation of air (that is, pressure increasing in the direction of flow with pumping).

The R45 is crossed inside a 1 800 mm diameter concrete jacked sleeve pipe. The annulus between sleeve and pipe is grouted up. Small diameter sleeves for cathodic protection cabling and possible future use were installed in the annulus before grouting.

**PIPE DESIGN**

Whilst the consultants’ original preference was a 10,3 mm wall thickness DN1500 mild steel, epoxy lined pipe, a 30 mm thickness cement lining (the preferred lining by the City of Cape Town) and maximum allowable velocity in the pipeline of 4 m\(^3\)/s were adopted. The thickness of the cement mortar lining was derived after extensive laboratory investigations and is the result of the aggressive and low pH levels (down to 2,9) of the water to be conveyed and high flow velocity adopted over the design life of the pipeline.

Pipes encased in concrete, generally below the river crossings, specials and valve chambers, and in Dasbos tunnel and adit are manufactured from 3CR12. The section of pipe inside the sleeve at the R45 crossing is of mild steel with a wall thickness of 20 mm to provide for additional safety in a position difficult to access. The individual pipes have been factory hydraulic tested. After installation and completion of the pipeline a further in-situ hydraulic test has been carried out. All pipes are continuously welded and joined by means of welding.

The selected corrosion protection system for the standard pipes consists of a factory applied 3,4 mm Sintakote (polyethylene) coating and a 30 mm cement mortar lining (CML) applied in two layers followed by a bituminous (Ravenol) coat which were applied in situ.

At the welds the pipe is wrapped with a shrink-on band. This is a double-layered bitumen/polyethylene band which is heat-applied on the prepared steel surface while overlapping the Sintakote coating on both sides. Pipes encased in concrete are coated with an epoxy paint.

The minimum cover on all pipes is 1,3 m. A cathodic protection system is also in place.

**WEMMERSHOEK RIVER IRRIGATION RELEASE WORKS**

The Wemmershoek Irrigation Release Works are positioned on the Wemmershoek River immediately upstream of the confluence with the Berg River and can release flows of up to 6,7 m\(^3\)/s through two DN600 sleeve valves. This facility enables irrigation releases to be made from either the Theewaterskloof or Berg River dams via the Dasbos and Drakenstein pipeline system into the Berg River. It consists of two DN600 sleeve valves housed in a concrete substructure discharging water with a head of up to 110 m into two chutes and stilling well. A building housing electrical and control equipment is erected on top of the chamber and above the 1:100 year flood level. For aesthetic purposes, and in order to blend into a future high-cost housing development, the outside of the building is clad with gabion baskets filled with small diameter river boulders.

**GENERAL**

The Supplement Scheme was constructed under three separate contracts. All pump stations, civil, tunnel and hydro mechanical installation works were undertaken by the Department of Water Affairs and Forestry Construction Division. All mechanical and electrical installations were undertaken by SULZER Pumps (SA).

The construction of the Dasbos and Drakenstein pipelines was undertaken by Cycad Pipelines. Costs for the construction of the whole of the Supplement Scheme are approximately R450 million.

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We wish to express our gratitude and thanks towards TCTA for permission to publish this article
CRBs facilitate building on steep slopes

LIFTING SWIMMING POOLS TO NEW LEVELS
How many homeowners choose the site for their new home because of the view? Probably millions of people do. The problem is that if you have chosen to build on a sloping plot with a stunning view, you might end up losing ground – quite literally. You can erect buildings on sloping ground using many different methods, but what if you want a swimming pool? The answer, of course, is to build a retaining wall to contain the ground around the pool.

If this is at all possible, you probably think that you’ll need an engineer, and it’s going to be expensive. A Cape Town-based company has proved that anything is possible with concrete retaining blocks (CRBs) – and you don’t have to rob a bank to do it!

The CRB system was pioneered in South Africa more than 25 years ago by local and international concrete block licensee Terraforce. It has since become well established in the marketplace, featuring qualities such as the ability to create retaining walls that are easily formed into complex curved shapes or walls in which the upper and lower profiles are continuously changing.

Because the blocks are reversible, the system offers a choice between round face (plant supportive) and flush face (smooth or split version) to suit specific site requirements. When installed, the blocks present a closed vertical surface structure that provides maximum amount of soil mass within the wall and prevents backfill spillage, while at the same time offering uninhibited permeability. Being hollow, yet strong, they require less concrete to do the job as compared to solid block systems.

A good example of a CRB system flexible enough to handle the challenges of a demanding site in an attractive and creative way is a pool and retaining wall that was built in Llandudno, in the Western Cape. The pool construction was done by Suburban Pools, and the wall was completed by Decorton, a specialist contractor for segmental retaining wall installations.

The installation of the supporting structure for the pool situated high up on solid granite rock outcrops required constructing a level foundation on the sloping and uneven granite rocks. This involved some core drilling and epoxy grouting of Y16 starter bars. Next, a reinforced concrete foundation was cast with steps at intervals to match Terraforce L12 block heights. The retaining wall was built to 3 m height using a concrete-filled double skin with steel reinforcing in the inner skin. The following 2 to 3 m were built with a concrete-filled single skin.

As work progressed, reinforcing geogrids were locked into the blocks, embedded in 4% cement-stabilised backfill, and tied again to sand bags filled with a specified cement-sand mix. These sandbags were used to provide the shape of the pool.

The CRB system is often used to create additional backyard space for a pool where it would otherwise have been difficult to do so. By using Terraforce L11 rockface blocks, builders provided a level, spacious platform about 3 m above road level, which surrounds the house built on a steeply sloping property. To soften the walls that support the fill for this platform, flower beds and steps were added. The 4 m wall at the back (the cut section) of the property was constructed in such a way as to provide a large backyard area where a swimming pool could be installed. The wall behind the swimming pool exhibits an artificial rock waterfall, along with more plantable space to soften the hardness of the high rock-face wall.

And yes, an engineer was involved, as this kind of installation requires a more demanding level of professional supervision than is required for standard retaining walls.

PUSHING BEYOND CONVENTIONAL BOUNDARIES
In the past, it was common knowledge that retaining walls had to be poured, reinforced concrete. Even though CRBs have been on the market for decades, there are still some who think blocks (especially hollow-core units) cannot do the same job as poured concrete, especially for structures higher than 4 m. That is simply not the case.

As an engineered structure, concrete block retaining walls offer extensive flexibility at a range of heights and in varied soil conditions when designed by experts in this complex field. The question about how high these structures can grow is
relatively governed by design engineers with the expertise to push beyond conventional boundaries.

Simon Knutton, a professional engineer and consultant with over a quarter century of local and international experience in this field, authored the first design guidelines for gravity walls in South Africa.

Commenting on the benefits of the Terraforce system, Knutton says: “The closed face of the Terraforce minimises the risk of erosion-induced failure, and the contact area from block to block is better on Terraforce than any other similar product.” Another advantage is that the wall angle is easily changed from near vertical to flatter slopes, and features such as stairs are comfortably incorporated.

Although composite Terraforce walls have been built to a height of 11 m with a single skin facing, it is important to note that there are certain limitations, and as a rule of thumb, any wall (with or without extra reinforcing) exceeding 8 m and with a wall angle of more than 65˚ will require either a double layer or concrete-filled blocks at the base to increase crushing strength, thus avoiding potential pressure cracks. Knutton also warns that terracing a wall can seem like a tempting solution – he remembers successfully reaching heights of up to 25 m in this way – as terraces effectively reduce the slope angle that the wall is resisting, but the temptation to use them can make a situation worse rather than better, since the foundation load from the upper wall can surcharge the lower one.

This does not mean terracing can never be considered for achieving greater wall height. Silvio Ferraris, a professional civil engineering technician from ReMaCon Products cc, a Gauteng-based concrete retaining block manufacturer, feels that it can be a good option, especially when space allows for it. As a basic guideline, the lower terrace must be approximately one third of the total wall height and the distance between terraces depends on overall wall height and overall horizontal space available. Generally, geofabric-reinforced lower terraces will offer greater overall wall stability. Most impor-

tiles in favour of higher tenacity products such as grids.

Concrete infill
Concrete fill has a similar effect to double skin in as much as the mass of the wall is increased per square meter. The concrete also improves shear resistance from block to block and boosts crushing strength. It is also possible to reinforce the concrete infill with steel or to incorporate vertical RC pillars or horizontal RC beams into the blocks.

Steel reinforcement
When considering the use of steel reinforcement in a concrete-filled wall, the block effectively is considered to be a combination of a shutter and a spacer. The use of reinforcement would require structural input to assess the efficacy of the whole system.

Interlocking keys
Concrete keys would only have value where there are higher than usual shear forces in a wall. They can either be plain coarse gravel infill, cement-stabilised soil infill or concrete keys. The soil inside the blocks should be tamped leaving a 50 mm gap. Once the next row of blocks is placed, the soil is tamped through into the 50 mm recess, effectively keying in the blocks.

Regardless of the methods described above, there are a few basic guidelines that need to be adhered to during the construction of a very high CRB-Terraforce wall, and Ferraris is very clear on how he would proceed. "A level foundation and an accurate first row is just the first step in many to ensure a safe and stable wall. Angled profiles need to be set up so that the wall angle will keep to the design slope. Compaction must be 93% mod AASHTO or more, and if possible, use soil material with less than 15% passing a 0.075 mm sieve. If that is not
possible, intermediate soil blanket drains and/or water transmissive geotextiles with adequate strength, as well as drains both at the base of the wall against the cut face and at intermediate heights, need to be considered. Drains should be placed against cut faces using either continuous sheets, if circumstances require, or ‘wick’ drains placed at between 1 m to 2.5 m centres and at 45° against the slope face.

Ferraris adds that in all cases, although this is difficult, all soils should be tested by a soils laboratory to determine the internal shear strength of soils, their cohesion, the percentage of fines and the plasticity index of both backfill soils and retained soils.

Nevertheless, each situation can call for a different solution and over the years many interesting and challenging Terraforce projects have been completed in South Africa and abroad. One such extensive retaining wall, completed within four months at Montecasino in Fourways, Johannesburg, boasts a face area of 2 700 m² and an average height of 9 metres. In this case Terraforce L13 blocks were placed on a 25 mpa concrete foundation and built to full height in chainages of about 60 metres.

The bottom 12 rows of blocks were filled with a cement-stabilised load-bearing mix, while the fabric-reinforced backfill was made up of 5% cement-stabilised soil (mixed with a TLB and placed with a telescopic loader) and compacted to 93% mod AASHTO. Light and heavy grades of woven geofabric were specified depending on their position within the wall. In situ concrete shear keys were installed on every row and every other block, including rows with fabric layers. All geotextiles were pre-tensioned in warp direction before placement of backfill material took place.

Often a steep property calls for steep measures, especially when vehicle access proves difficult. In the following case the client purchased two properties, a vacant stand and an existing house, in an exclusive real estate area. The house was demolished and extensive earth works carried out to prepare the site for the new house and build a driveway up to the level of the new garage. To achieve this, the engineers designed reinforced concrete retaining walls on both sides of the driveway. Above that level, Terraforce L11 retaining walls were used to a height of 9 m.

These were constructed on reinforced concrete foundations that were in turn held in position with anchors through the foundation. At predetermined positions, vertical reinforced concrete columns were incorporated into the blocks. These were in turn linked to another, horizontal reinforced concrete beam approximately halfway up the wall height, which was tied back with soil nails up to 7 m long into the benched embankment behind the walls.

Due to poor access to the site and to reduce the cost of removing and importing suitable fill material, it was decided to use the excavated decomposed granite material as backfill. To make this problematic fill work, it had to be reinforced with horizontal layers of restrain 50 geofabric placed at various levels in the backfill and locked into the L11 block-facing layer. To improve service access, various terraces were specified between walls, with stairways connecting them. Hardy creepers and ground covers were planted, and an irrigation system installed to ensure an even, green cover in a short space of time.
Massive retaining wall project at FNB-Wesbank development

THE NEWLY COMPLETED FNB-Wesbank administrative centre in Fairland, Johannesburg, is a development which has generated considerable interest among construction professionals and members of the public alike, owing primarily to some highly innovative architecture used in its design by Kim Fairbairn of Continuum Architects (Pty) Ltd.

Having been built on a site with a marked and varied slope, it is a development which required extensive retaining wall support.

A total of eight retaining walls were built, some of which reached heights of 7.5 metres. These cover an area of some 3 000 m² and used close on 30 000 concrete retaining blocks (CRBs) in their construction. CRB walls are more cost-effective than conventional reinforced concrete walls and are considerably more attractive, facilitating as they do varying shapes and contours, as well as the growth of plants in the soil-filled blocks.

All the walls were built by Kalode Construction using INFRASET’s Terrace Block retaining system, the one exception being an internal wall in the Basement 3, which was built using Concor Technicrete’s Envirowall block system. This wall comprised a geogrid-reinforced fill structure built at 85° – the Envirowall block is best suited to this type of application.

The walls were built in two phases. Phase 1, which comprised the Basement 3 wall and the fire escape structured fill wall on the northern side of the project, was designed by John Joubert of Foundation and Slope Stability Engineering, and Phase 2, which consisted of the remainder of the walls, was designed by Herman Pietersen of Herman Pietersen and Associates.

Anyone visiting the site for the first time will immediately be confronted by a retaining wall at the Wilson Street entrance. Although not part of the FNB-Wesbank development per se, it was also constructed by Kalode Construction on behalf of Brian Wescott Construction. Completed in 2006, the wall was built on the southern slope of the feeder road which serves both the FNB-Wesbank development and Worldwear Shopping Centre adjacent to the FNB development. A pure gravity structure, the wall is 60 metres end-to-end and reaches three metres at its highest point.

Further evidence that retaining walls play a crucial role at this site becomes apparent at the gatehouse where 5 000 CRBs were used to create an attractive 80 metre wall. Once plants and flowers are established on this section of wall it will form an extremely attractive feature. The wall itself entailed a standard
design and installation. It rests on a concrete strip footing 200 mm deep by 600 mm wide, tops 4.5 metres at its apex, and for the most part, slopes at an angle of 70°. Blasting was necessary on parts of this section and the exposed rock face was covered with CRB blocks.

One of the more challenging CRB projects at the FNB site was a wall built to support a fire escape on the north-western side of the development. Seventy metres long and seven metres high, it was built at an angle of 70°. The fill in this wall is well compacted and reinforced with high strength polyester geogrids supplied by Kaytech. The fire escape sits directly on the structural fills and applies loadings on these fills of 150 kPa.

The wall built with Concor’s Envirowall blocks is a vertical structure situated in the basement, which houses the building’s fire fighting equipment. Approximately 14 000 blocks were used on this wall and Kalode were responsible for all the fills and the stabilising.

This wall was offered as an alternative to the originally proposed retaining wall as it was much more cost effective, by approximately 40%. Just on 100 metres long and reaching a height of 6.8 metres, the top half of the structure was reinforced with tensioned polyester geogrids which extend into the backfill. The bottom 2.5 metre section of the wall is constructed with a 5% cement-stabilised fill reinforced with tensioned polyester grids.

Kalode Construction managing director, Jan Pienaar, says Envirowall blocks were used on this wall as they are ideal for vertical structures that are heavily loaded. The bottom two metre section of the wall is cement-stabilised and soil-reinforced with stretched geogrids supplied by Kaytech. The top 4.5 metres is a conventional stretched soil reinforced structure with the blocks acting more as a facing than a structural element.

On the south-eastern and south-western section of the building a sunken wall 6.5 metres high and 93 metres long was built at a slope of 70°. A composite wall, it was constructed with a double skin up to a height of four metres and a standard geogrid reinforced fill was used above that to maintain the weight.

Another wall section, the south-western pod, was built around a staircase. It is also a composite structure in which cement-stabilised soils and geogrids, as well as plain geogrid-reinforced fills and terraced stepbacks were used to accommodate the staircase landings and to break the stark lines of a high CRB wall situated in confined surroundings. It is 125 metres long, varies between three and eight metres in height, and has a 70° slope.

All structures were built with adequate subsoil drainage consisting of clean stone wrapped in horizontally-laid Kaytape A2. Wick drains 250 mm wide were laid on the face of the exposed embankment and these act as sub-soil cut-off and collector drains.

INFO

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This 70 m x 7 m high retaining wall, built with INFRASET Terrace Blocks, supports a fire escape and is situated on the northern side of the FNB-Wesbank development in Fairland, Johannesburg

A 140 m x 7.5 m retaining wall built with INFRASET Terrace Blocks on the southern side of the FNB-Wesbank development in Fairland, Johannesburg
IN BRIEF

MASDAR INITIATIVE IN ABU DHABI FOCUSES ON ALTERNATIVE ENERGY SOURCES

A COMBINATION OF circumstances is leading to less reliance on petroleum products as the primary source of energy for the world: environmental concerns over global warming caused by greenhouse gas emissions, increased costs of oil, and the eventual depletion of the oil reserves. These driving forces have stimulated efforts at developing alternative energy sources – solar, wind, biomass, etc.

Oil rich countries have been slow to recognize that the demand and supply of their petroleum reserves is changing. At least one of the richest oil producing countries, sitting on some 10% of the proven reserves in the world, has recognized the impending developments and has chosen a strategic path forward. The emirate of Abu Dhabi in the United Arab Emirates (UAE) has taken action to invest a significant portion of its current oil revenues in developing alternative energy sources for the future.

The Masdar Initiative in Abu Dhabi is focused on developing alternative energy sources as an economic base for the future of the country. It includes the Abu Dhabi Future Energy Company, which is investing in exploiting current alternative energy technologies and the Masdar Institute of Science and Technology, which is developing graduate education and research programs to build human capacity for the future.

The Masdar Institute of Science and Technology is developing masters and doctoral programs, and research activities, relevant to alternative energy. It is to be housed in a green-zone new demonstration city which is designed for zero carbon emissions.

The Government of Abu Dhabi has established the Masdar Institute of Science and Technology to meet the exceptional and progressive goal of transforming its economy from one based on petroleum to one focused on sustainable technology and renewable energy. This new, private graduate Institute positions Abu Dhabi to make an historic transformation and to become a knowledge hub for global innovation.

Developed with the support and cooperation of the Massachusetts Institute of Technology (MIT), the Masdar Institute of Science and Technology (MIST) is an independent, not-for-profit, research-driven institution focused on science and technology. MIST will educate a workforce that will be prepared to compete in global markets and participate in research and development with an emphasis on alliances with global corporations and entrepreneurial opportunities.

MIT is assisting the Masdar Institute of Science and Technology in four integral areas: (1) joint collaborative research; (2) development of degree programs; (3) outreach that encourages industrial participation in research and development activities of MIST; and (4) support for capacity-building at MIST in terms of its organization and administrative structure, as well as scholarly assessment of potential faculty candidates for the Institute.

INFO

Dr Russel Jones
www.mist.ac.ae

HOT DIP GALVANIZING INDUSTRY ACKNOWLEDGED AT AFRICA ENERGY AWARDS 2008

THE HOT DIP Galvanizers Association Southern Africa (HDGASA) received
the Award for the Best Environmental Rehabilitation Project at the Africa Energy Awards held on 16 April 2008.

The finalists in this particular category were the Vanilla Development Foundation in Kenya and the HDGASA, who submitted an entry on behalf of the hot dip galvanizing industry.

The hot dip galvanizing industry has for more than 50 years been a major supplier to the Southern African power distribution industry. It has been at the forefront of supplying the primary corrosion control requirements that are used to provide long-term service life and sustainability of a wide range of steel structures used in this sector. Power transmission lines, sub-station steelwork and numerous other ancillary steel installations throughout the Southern African region have been hot dip galvanized as the primary means of protecting steel structures that are subjected to the destructive corrosive elements present in a wide range of differing environmental conditions.

To win this award the entrant has to meet the category criteria, i.e. enhancing environmental benefits and meeting the government requirements of environmental rehabilitation. On receiving the award, Robert Wilmot, Executive Director of the HDGASA, said that zinc, used in the hot dip galvanizing process, is regarded as one of man’s friendly metals as it is essential for all forms of growth, does not contaminate or harm the environment, and has the ability to provide long-term corrosion protection of steel structures at extremely economical life cycle rates.

**WORLD RIVERS DAY SET FOR 28 SEPTEMBER**

WITH MANY OF the world’s rivers facing severe and mounting threats associated with climate change, pollution, and industrial development, the British Columbia Institute of Technology (BCIT) and the Canadian branch of the United Nations (UN) Water for Life initiative are encouraging countries and conservation groups around the world to participate in this year’s fourth annual World Rivers Day (WRD) on 28 September.

“Rivers are the arteries of our planet and yet many waterways continue to suffer from inadequate protection and inappropriate practices,” says Mark Angelo, WRD founder and program head of the Fish, Wildlife and Recreation program at BCIT.

Angelo, a member of the Order of Canada and an inaugural recipient of a UN Award for Science, Education, and Conservation, initially founded the Rivers Day event in British Columbia before successfully lobbying numerous organisations and agencies of the UN to recognise WRD in 2005. Marking a global response to the need to better manage and conserve river ecosystems, WRD celebrates the many values of the world’s waterways while encouraging appropriate action to better protect rivers and streams. The event is also intended to compliment the UN’s worldwide Water for Life initiative.

Endorsed in its inaugural year by UN agencies such as the United Nations University and the International Network of Water, Environment, and Health, WRD events can and will include river clean-ups, fish enhancement projects, stream restoration initiatives, workshops, educational programs, and community riverside festivals. Last year events took place in countries ranging from Canada to England, Poland to the United States, Taiwan to the Congo, and from Togo in West Africa to the island of Dominica.
Founded by Angelo in 1980, British Columbia Rivers Day has since become a template for WRD with close to 100,000 people participating in British Columbia alone. WRD fosters an increased awareness of water-related issues and promotes core values associated with sustainability, conservation, and river stewardship.

All countries are encouraged to participate. For further information or to register an event, visit http://www.worldriversday.bcit.ca.

NEW FACET TO SA’S FAST-GROWING RECYCLING INDUSTRY

RECYCLING OF MATERIALS for reuse in South Africa is a fast-growing industry. Now a new facet has been added to the business – the recycling of slag.

The latest move comes from National Scrap Metals at Kuilsrivier, Cape Town, a company that is serious about protecting the environment and South Africa’s natural resources. National Scrap Metals currently holds two international ratings, the ISO 14001 and the ISO 9001, and is working towards an ISO 18000 that may be awarded by the end of the year.

Major shareholders in National Scrap Metals are Murray and Roberts and the New Reclamation Group.

According to Adri Vosloo, general manager of National Scrap Metals, Cape Town, the company had recently purchased sophisticated equipment from Pilot Crushtec – a Finlay 663 Supertrak, which is a mobile track-mounted diesel-driven screening plant, and a Modular MJ1252 skid-mounted electric granulator jaw crusher, manufactured by Pilot Crushtec. He added that the facility is seen to be a ‘pilot’ operation that is expected to develop nationwide as investigations into possible uses of crushed slag continue.

The Kuilsrivier plant is currently processing 3,500 t/m of slag from the Murray and Roberts-owned Cape Town Iron and Steel, while additional material from a stockpile is also being fed into the system. Crushed slag is currently going to the construction industry to be used as filler and for road manufacture, as well as to manufacturers of specialised bricks. Interest in the product is growing, and sales are increasing.

National Scrap Metals had purchased modular crushing and screening equipment from Pilot Crushtec in 2003 as a trial with the purpose of extracting metal from an existing waste dump while crushing slag. The decision to upgrade was taken recently when growth in demand for crushed slag started to develop. Currently the new jaw crusher is being used to enhance the production of the modular plant that, together with the Finlay 663 Supertrak, is delivering products from very small to 50 mm. Vosloo says that production is flexible and different sizes of material can be provided to meet customer needs.

Nicolan Govender, national sales manager for Pilot Crushtec, confirms that the recycling industry is growing fast, especially in the Western Cape and Gauteng.

“We see more recycling taking place on site for material to be reused, to avoid increasing transport costs and the increased costs of dumping at waste sites. Strong growth is seen particularly in the construction industry, though mining in Southern Africa is now also focusing more on recycling.”

According to Govender the Pilot Crushtec Modular MJ1252 skid-mounted electric granulator jaw crusher is a new model in the Modular range and two are already being used in the mining industry. More than 20 Finlay
Supertrak models have already been sold into the recycling industry in South Africa.

New Waterproofer to the Aid of Seal Pups

a.b.e. Construction Chemicals was recently approached by Seal Alert in Hout Bay for technical advice on an effective way of waterproofing the holding tanks in which seal pups, who had been washed ashore, are housed before being released to the sea.

Seal Alert rescues these day-old pups from the beaches after exceptionally high seas or culling had orphaned them. Once the seals have grown to a size where they are able to fend for themselves, they are released into the sea at Hout Bay where a few rafts are moored specifically for this purpose.

Dave Papayanni, Technical Sales Representative of a.b.e. Construction Chemicals in the Western Cape, says Seal Alert’s one holding tank had already been waterproofed with a.b.e.’s Super Laykold waterproofing product. “But, although the product provided extremely effective waterproofing, the ‘black’ sealing system proved a problem. The depth perception of seal pups is poor, and the black colour aggravated this, resulting in them falling off the upper landing of the tank, injuring themselves.”

a.b.e. donated a few cans of its new Fibrated Super Laycryl seamless waterproofer, which is produced in eight colours, to apply in a grey version to avoid the black appearance of the bottom of the tanks. Fibrated Super Laycryl is not designed for continuous immersion in water, but in the short term it has served the purpose of preventing injury to the pups.

“In fact,” Papayanni added, “six months later, despite its total immersion in water,
THE SIMBITHI ECO-ESTATE PROJECT

The 430-hectare Eco-Estate lies in the heart of KwaZulu-Natal’s northern coastline. This natural coastal paradise has dense, indigenous riverine vegetation, lush valley wetlands, undulating hills and breathtaking vistas. But it was the intricate design which involved the maintenance of a 30 m buffer zone from the wetland area for conservation that made this project memorable. Louise Le Cordier from Makanyane Consulting Engineers describes the project:

“The first phase of the project was completed by Kwezi V3 Engineers and comprised approximately 1 000 units, made up of single residential and medium density residential sites linked by a network of internal roads. Makanyane Consulting received the green light for phases 2, 3, and 4, which comprised a further 434 units designed around an 18-hole executive short course. Although this project was extremely demanding, it was one of the most exciting projects to work on.”

The dream team of this dynamic company consists of Louise, as senior partner, and her two fellow partners, Akram Khan and Gary Visser. Each member of the Makanyane team brings a unique set of skills which has created an unmistakable synergy and has led to the procurement of high-level contracts in short succession. The Simbithi Eco-Estate was one of the first projects that the company was awarded when it first opened its doors in 2004.

Every possible precaution was taken to minimize environmental impact during the completion of the Simbithi project. Various initiatives included geology and soil assessments, water resource and drainage appraisals, land use and vegetation studies, as well as aesthetic, historical and cultural appraisals to ensure that the development would be perfectly in tune with its natural surroundings.

According to Louise, the intricate project design was detailed with the help of infrastructure software design packages Civil Designer and AllyCAD. “We tested the software to the full during the extension of the Simbithi Eco-Estate on 60,63 ha, which accommodated 288 residential units, with a new service entrance and administrative centre for the estate. There was also the design of a new arterial road reserve that ran parallel to the N2, the relocation of all the existing overhead power lines to underground cables and the installation of the server mains to link to the existing bulk reticulation.”

One of the biggest environmental challenges during the execution of the project was that a 30 m buffer zone from the wetland had to be maintained for conservation purposes. This placed considerable limitations on the design team, but was necessary to ensure that a strict code of compliance in the Environmental Management Plan was adhered to. According to Louise, a buffer surrounding the wetland served several functions: “A buffer would reduce the level to which pollutants and sediments directly enter the wetland, as some of these elements would be trapped before entering the wetland. It would also provide some adjacent natural habitat, which reduces the isolation (from other natural areas) to which many wetlands in urban areas are subjected.”

Other advantages provided by a buffer include the fact that the value of a wetland for supporting biodiversity is derived not only from the quality of habitat contained within the wetlands, but also from the linkages it has with other natural areas, because many wetland-dependent species move between wetland and non-wetland habitats. Without a buffer, it becomes increasingly difficult to carry out necessary management practices in the wetland, and it also reduces the proximity of human presence which directly disturbs wildlife.

The Environmental Management Plan, which had to be approved prior to construction, made provision for strict requirements. The Plan made allowance for the downstream maintenance of the ecological reserve, and in addition, the water quality could not be adversely impacted during the construction of the proposed dam walls, which had to be designed to include a diversity of habitats for fish and wading birds. Also, soil erosion on site had to be prevented, or where applicable, controlled at all times. Other considerations included the replacement of the existing gum plantation with indigenous vegetation during the execution of the project.

A high level of community interaction amidst the numerous environmental restrictions added further complexity to the project. Louise mentions that provision was made for public participation at an early stage already. This involved numerous public meetings to discuss and address concerns by members of the community. One of the concerns raised had to do with the valleys and wetlands which had previously been planted with sugar cane. In these cases the grasslands and coastal forest were rehabilitated and indigenous game...
species reintroduced. Louise notes that, since the planting of indigenous vegetation to rehabilitate the site, the entire area has been enhanced.

Long-term strategies had also been included in the program. “Rather than exclusively planting indigenous trees and excluding fire in all the wetland areas, thereby encouraging the wholesale extension of swamp forest, the Environmental Management Plan prescribed that herbaceous areas should be maintained on the site. In order to do so, a burning program, as well as a controlled grazing program, was drawn up for these areas to contribute to the promotion of habitat heterogeneity within the herbaceous wetland areas.”

Despite the many challenges on the project, the well-known Simbithi Eco-Estate will continue to set the footprint that other eco-estates are likely to follow, making it a landmark project.

INFO

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SA BUILDERS TO MEET AMIDST SEVERE CHALLENGES

THE MASTER BUILDERS South Africa (MBSA) 2008 annual congress in Port Elizabeth in September will be held against a backdrop of one of the most critical stages in the history of the South African building industry.

Eunice Forbes, president of the MBSA, says the upsurge in activity in the building sector over the last two years has substantially challenged the industry and highlighted the crippling shortage of skilled artisans. She feels that the industry has to drastically improve its training programs to cope with the demands not only of the 2010 Soccer World Cup, but also the more general growth projects which should continue long beyond 2010.

“MBSA also strongly feels that the necessary exit clauses for imported labour should be put in place to ensure that South Africans are not excluded from jobs after the Soccer World Cup. The potentially devastating effect of AIDS on our already precarious workforce also needs urgent attention,” she stresses.

Pierre Fourie, CEO of MBSA, says the building industry is now under unprecedented pressure to preserve environmental resources and lessen its negative impact on the planet. “The restrictions and conditions of the ‘Green Building’ wave sweeping the world have already reached South Africa, where the building industry still has much to do in this regard. The building industry also has the power supply crisis to contend with. The opportunities for national networking and decision-making toward unified solutions offered by this congress come at a vital time for our sector.”

The MBSA 2008 congress will be held at the Boardwalk Conference Centre in Port Elizabeth from 21 to 23 September. Guest speakers already secured include Thoko Didiza, the Minister of Public Works; Neil Cloete, MD of Grinaker-LTA; Pepi Silinga, Chief Executive of Coega IDZ; Samuel Isaacs of the South African Qualifications Authority; Aubrey Matshiqi of the Centre for Policy Studies; Daniel Silke, futurist; Claire Deacon of Occumed; and André Fourie of the National Business Initiative.

The annual MBSA National Safety
Competition awards will be made after the congress which will also feature a display of building material, and suppliers’ products and services.

Port Elizabeth’s The Boardwalk Conference Centre will be the venue for the 2008 MBSA Congress.

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DEMAND FOR C&CI TRAINING SOARS IN MIDST OF BUILDING BOOM

THE CEMENT & CONCRETE Institute’s School of Concrete Technology is experiencing unprecedented demand for its services as the South African construction sector tries to cope with a shortage of skills in the midst of a building boom.

According to Bruce Raath, C&CI Education and Training Manager, the School of Concrete Technology exceeded the projected student numbers and income for the first four months of this year. Raath says that not only are all planned courses well-attended – and in many cases over-subscribed – but the demand for unscheduled courses has also increased, stretching the availability of venues and lecturers to capacity.

The projected number of student days for the first four months of 2008 had been around 800 whereas the actual days reached almost 1 200.
Raath ascribes this upswing in training (which has been noticeable for the past 18 months) to the urgent need for skills, the extremely busy construction sector and, in the case of professional staff, the need to accumulate Continuing Professional Development (CPD) points.

C&CI has also announced that it will step up its involvement in tertiary education in South Africa to ensure the future of the engineering profession and to increase awareness of concrete as building material. For the remainder of 2008, C&CI will concentrate on universities and, from 2009, universities of technology will also be included.

An educational program of lectures, laboratory work and site visits is already under way for 165 second year Construction Management students at the University of the Witwatersrand, with a program aimed at second year Wits Civil Engineering students also in place. Similar educational packages are planned for around 100 second year civil engineering students from the University of KwaZulu Natal during the second half of this year.

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ARCUS GIBB ACQUIRES AFRICAN CONSULTING ENGINEERS

ARCUS GIBB Holdings have purchased African Consulting Engineers, trading as GIBB Botswana and GIBB Swaziland. This purchase gives ARCUS GIBB Holdings the licensing rights to the GIBB trademark exclusively in a number of African countries. It also brings together all the GIBB operations in the SADC region under a single owner, i.e. the ARCUS GIBB Staff Trusts representing ARCUS GIBB employees.

The acquisition is in line with ARCUS GIBB’s strategy to grow the company into the rest of the continent, whilst using their well established GIBB brand. Botswana’s state of business is very healthy and ARCUS GIBB will be able to run successful projects there for several years. Operations in South Africa will also continue to benefit from projects in these countries, as some members of staff are involved with projects like the Thune Dam, the Gaborone Sewers, and road upgrades. Vernon Joubert will continue in his role as Managing Director of the Botswana Operations, reporting directly to CEO Richard Vries.

ARCUS GIBB CEO Richard Vries says, “We want to take the opportunity to welcome the Botswana and Swaziland staff as they now become fully integrated into the GIBB Group. We also hope that, through this acquisition, we have created more opportunities for all our staff members to work on exciting projects throughout the region.”

Richard Vries (CEO ARCUS GIBB) concludes the purchase transaction with Richard Gordon of African Consulting Engineers.
Top management changes at Vela VKE

Arthur Taute has stepped down as CEO of Vela VKE to take up his new role as Managing Director of VKE International and head of the IT Division. In his place Dr Tom Marshall, who has been with Vela VKE for 26 years, has been appointed CEO. He was previously head of the Development Division and Chief Operating Officer, and is on the Board of Directors.

Arthur Taute became CEO of VKE in 1998. Under his leadership VKE experienced substantial growth and economic success, and was transformed to an employee-owned firm with more than 150 shareholders. Black management in the firm was enhanced dramatically and black ownership increased to 31%. As a symbol of the transformed nature of the firm, the name was changed to Vela VKE and a new logo was adopted. During Arthur’s tenure VKE ventured into the USA where an office was opened in Atlanta, later moving to Portland. Arthur is enthusiastic about the future of Africa and believes that the continent has the human capacity to become an economic force to be reckoned with.

Cecil Rose appointed to CIDB

Cecil Rose, who had served as president of the South African Association of Consulting Engineers in 2006-2007, and who is also a member of SAICE’s Western Cape Branch, was recently appointed by the Minister of Public Works as Deputy Chairperson of the Construction Industry Development Board (CIDB). This appointment comes at a time when CIDB activities are beginning to impact more on the professional sector. The CIDB is currently developing a register of Professional Service Providers which would include architects, consulting engineers and quantity surveyors who wish to do work for the state or any of its entities. With this appointment Cecil joins a number of prominent SAICE members who have been, or still are, active within the CIDB leadership. Of particular note in this regard are four previous presidents of SAICE, namely Brian Bruce, Rodney Milford, Trueman Goba and Sam Amod.

Spending time in Nigeria

ARCUS GIBB has been appointed by the Rivers State Government to prepare a Development Plan for the redevelopment of Port Harcourt, Nigeria, as well as the design of the first phase of a new city providing up to 20 000 housing opportunities. Lintle Maliehe and Gillian Wayman were accepted as Local Resident Project Coordinator and Coordinator’s Assistant respectively, and will remain in Nigeria until February 2009. Together the two women, who have been in Nigeria since 1 May of this year, are responsible for the smooth running of the Port Harcourt project. Lintle joined ARCUS GIBB in May 2007, while Gillian Wayman has been with ARCUS GIBB for over 15 years.
NSTF Awards’ tenth birthday – and a present for SAICE

DURING AN ILLUSTRIOUS gala dinner, which marked the tenth birthday of the National Science and Technology Forum (NSTF) Awards, various individuals and groups were honoured for their outstanding contributions towards scientific, engineering and technological (SET) development during 2007. The Minister of Science and Technology, Mr Mosibudi Mangena, who is also the patron of the NSTF, presented the awards. Winners were selected from more than 70 nominations. The event is unique in that it affords an opportunity for recognition to all practising scientists, engineers and technologists across the spectrum of innovation, including, for example, teachers and students in mathematics, science and technology.

Denis Hunt, the chief adjudicator explained the theme, *Today’s research – Tomorrow’s innovation*, and emphasised the contribution that dedicated individuals, either working by themselves or as part of an organisation, can make towards improving the quality of life for current and future generations. It is clear that South African SET is on a par with global standards. It is also important to take note that great innovation is only really achievable through people. South Africa can be proud of the NSTF Awards winners and nominees.

ALLYSON LAWLESS
It was with great joy that we witnessed SAICE’s Allyson Lawless winning in the category for ‘Activities other than research and its outputs over the last five years or less’.

During her year as the first lady president of SAICE in 2000, Allyson became acutely aware of the skills shortage in the civil engineering profession and undertook a project across the country, which covered interviews, questionnaires and research and its outputs over the last five years or less.

continued on page 79
THE PARLIAMENTARY PORTFOLIO Committee on Water Affairs and Forestry called for submissions on “water quality and pollution challenges facing South Africa”. Hearings were held over two days at Parliament in Cape Town. Presentations were made by a number of bodies – such as the CSIR and Eskom, DWAF, a number of municipalities, and activist groupings. Dr Kevin Wall, president of SAIC in 2001, made a presentation on behalf of SAIC.

He started the presentation by describing the water cycle, the water services delivery process, and the integrated nature of this process. Hence, he said, the delivery results would only be as strong as the weakest links in that process. Drawing on the findings of SAIC (such as in the infrastructure report card) and of other organisations (in particular of the CSIR), he sought to show that the weakest link was more often than not in respect of skills, followed, some distance behind, by both finance (budget constraints in particular) and the management and leadership of the water services institution.

He outlined the main water-related legislation and strategies, saying that these were good, but that the problem lay in implementation.

As befits a learned society, SAIC had put a lot of effort into understanding the issue of skills. He presented the results of surveys, undertaken in particular by Allyson Lawless, and ran through a number of matters of concern, including the need to rebuild civil engineering capacity, and to outsource, both of which require capacity in the water services institutions.

Kevin concluded by outlining the various programs of SAIC, in particular ENERGYS, and by pleading that elected representatives treasure their engineering personnel, and listen to their advice! And if there was one thing outside the water sector, and hence outside the purview of the Portfolio Committee, that the committee members could nonetheless, as MPs, try to influence, it should be to do what they can to improve the primary and secondary education system.

The presentation was followed by discussion and questions from the committee members. The chairperson, Ms Connie September, concluded by saying that she would welcome further submissions, and a continuation of the “ongoing relationship that she enjoyed with SAIC.”

Kevin Wall presenting Ms Connie September (MP and Chairperson of the Portfolio Committee on Water Affairs and Forestry) with a SAIC Outreach pack. Looking on is Lemias Mashile (MP and SAIC Council member).

We welcome a new editor!

TEN YEARS AGO

Verelene de Koker joined SAIC’s frontline contact - the voice on the switchboard. Prior to that she had been administering SAIC’s SPEBS bursary scheme from home for a number of years. She continued administering the scheme as part of her regular office duties until 2005 when the administration of the scheme was outsourced.

At the beginning of 2001 Verelene moved to the Communications Department where her main task was serving as secretariat for the SAIC magazine and journal. In this position she honed her already formidable writing skills and gained extensive experience in the general management of the magazine and journal. In the process she also built up an effective network of SAIC contacts.

Verelene’s appointment to the position of editor brings the magazine back in-house, after a spell of close on forty years, during which time SAIC’s editor had always been a contractor based outside the National Office structure. This move, incidentally, brings to fruition an idea that had been mooted more than eight years ago, namely that SAIC should strengthen its editorial position by fostering closer links with its constituents.

Welcome to the editor’s chair Verelene!

Dawie Botha
SAIC Executive Director
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REVISED “LOADING CODE” TO BE RELEASED FOR COMMENT BY PROFESSION

The SAICE Working Group will complete final revisions to the new SANS 10160: Basis of structural design and actions for buildings and industrial structures by the end of July. It is intended that the revised code should be available for comment by the profession in October 2008.

The code, commonly referred to as the “loading code”, has been substantially updated since the last revision of its predecessor SABS 0160 in 1993. These updates bring the code in line with ISO reliability standards and achieve substantial compatibility with the Eurocodes. The sections on basis of design, wind actions, crane induced actions and seismic actions have been extensively revised and a new section on the basis of geotechnical design has been added.

Following approval of the Committee Draft by STANSA sub-committee SC5120.61M, the draft standard will be posted on the SABS web site where it will be open for review and comment by the profession for a period of 60 days. After consideration of the comments received and necessary amendments to the draft, the final document will be issued as a South African Standard early in 2009.

A series of seminars are to be held throughout the country during which the revised code will be presented to the profession. The intention of these seminars is to highlight the changes made to the code and the background to these changes. Provisional dates and venues for these seminars are as follows:

- 7th October 2008 Port Elizabeth
  Summerstrand Hotel
- 9th October 2008 Cape Town
  Belmont Conference Centre
- 14th October 2008 Durban
  KZN Master Builders Association
- 16th October 2008 Gauteng
  Eskom Conference Centre

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GEOTECHNICAL DIVISION’S POSITION ON A SA GEOTECHNICAL DESIGN CODE

On 22 May 2008, geotechnical designers from around the country met at SAICE’s offices in Midrand to discuss the way ahead for the implementation of a South African geotechnical design code. The discussions were prompted by the provisions made in the revised SANS 10160: Basis of structural design and actions for buildings and industrial structures for geotechnical design and the compatibility of this code with the Eurocodes.

Three possible courses of action were debated at the meeting. These were:

1. Adopting EN1997-1 (Geotechnical Design – General Rules) as a South African design code. This will entail writing what amounts to a South African National Annex to the code.
2. Writing a South African design code based on SANS 10160 and EN1997. This code would contain only those aspects of the Eurocode relevant to South African conditions.
3. The laissez-faire approach. This is effectively the current situation where, in the absence of a geotechnical design code, designers use whatever design method is best suited to the problem at hand.

Option 3 above was seen as the easy way out but does not hold any benefits for the profession.

The meeting agreed that drafting a South African design code would be beneficial. The new code would be a practical design code, relevant to South African conditions, written by engineers for engineers. The main drawbacks are the amount of time required to write such a code and that it would be difficult to write a code of this nature before the profession has more experience in the use of limit states design in geotechnical engineering.

The meeting agreed that geotechnical designers should be encouraged to use EN1997-1 in conjunction with SANS 10160 over the next few years. Thereafter, a more informed decision can be taken whether to adopt or adapt EN1997-1 or another international design code. This agreement was ratified by the Geotechnical Division Committee during their meeting later on the same day.

Anyone interested in participating in such a programme of trial implementation of EN1997-1 is welcome to contact the Geotechnical Division for further information.

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THE DEPARTMENT OF Civil Engineering and Surveying at the Cape Town campus of the Cape Peninsula University of Technology held its annual award ceremony earlier this year where prizes were handed to deserving students for their achievements during 2007.

Here Taryn Jones receives the SAICE award for best third year student from Alan Proctor, course head in Civil Engineering. Taryn also received the trophy for the best student in all three years of the National Diploma in Civil Engineering.

BKS-SAICE ‘Take a girl-child on site’-day

IN 2007 SAICE and BKS took the liberty to change Cell C’s ‘Take a girl-child to work’ day to ‘Take a girl-child on site’ day in support of the Cell C initiative. Earlier this year, 30 girls from the Umqhele Comprehensive School in Ivory Park, Midrand, were taken to the BKS construction site at UNISA to show them what civil engineering is all about. In the photo structural engineer Kim McKenzie from BKS briefs the girls. Earlier in the day the girls attended presentations on civil engineering projects, where they also learnt what infrastructure is, why it should be maintained, and why the country needs civil engineering professionals.

SAICE and BKS hope that this initiative will be adopted country-wide as a way to expose learners to the civil engineering profession and inspire them to consider the profession as a career.

CPUT student receives SAICE award

THE DEPARTMENT OF Civil Engineering and Surveying at the Cape Town campus of the Cape Peninsula University of Technology held its annual award ceremony earlier this year where prizes were handed to deserving students for their achievements during 2007.

Here Taryn Jones receives the SAICE award for best third year student from Alan Proctor, course head in Civil Engineering. Taryn also received the trophy for the best student in all three years of the National Diploma in Civil Engineering.

SAICE Student Chapter UCT

THE SAICE STUDENT Chapter located at the University of Cape Town caters for the needs of all civil engineering students who would like to extend their interest in their chosen profession. The student chapter committee endeavours to facilitate talks and discussions with men and women representing different environments within the civil engineering profession, as well as with professionals from related fields who have an influence on the engineering profession in and around Cape Town.

A previous talk on “What to expect on your first day of work, as a civil engineer” gave students an idea of the day to day operations in a civil engineering design office and on the contractor’s playground. Students were briefed on this topic by Jeffares & Green executive associate, Chris Wise, who is also a UCT civil engineering alumnus.

Talks planned for the future include a briefing by Highveld PFs on graduate recruitment, financial consulting, tax information, and financial benefits analysis. These talks would give students a perspective on aspects of their chosen profession that are not taught in the more ‘science based’ class environment. Through these talks students are exposed to the working world and the realities of financial benefits and work packages. A 2010 soccer world cup presentation has also been planned for the near future, which promises to attract many eager students.

The Civil Engineering Department at UCT caters for some 350 undergraduate and postgraduate students of whom 240 are currently SAICE student members. Students have responded positively to this fairly new initiative, which is encouraging, given that the chapter is only in its second year of operation. Students may also participate in the monthly presentations of the SAICE Western Cape Branch. These are often very educational and encourage deeper learning.

Committee members of the SAICE Student Chapter at the University of Cape Town
From left to right: Bruno Salvoldi (treasurer), Maksotsene Makgalemele (outreach), Lydia Holze (deputy chair), Michael Vice (chair), Charles MacRobert (secretary), Cheri Hobson (events manager)
workshops for and with students, graduates and other sources of input. This culminated in the publication of ‘Numbers and Needs: Addressing Imbalances in the Civil Engineering Profession’ and a second, similar analysis of the local government situation. These have changed perceptions regarding scarce skills in South Africa where for the first time the extent of the engineering skills shortage has been measured and published. The work is frequently quoted when the topic is addressed at the highest level. The interventions suggested in the books are being very successfully implemented, e.g. through the ENERGYS project for which purpose SAICE established a section 21 company. UNESCO has proposed that the work should serve as a model for studies in other African countries, as well as in certain first world countries.

**TRAC**

We were equally delighted when another civil engineering-connected winner was announced, this time in the category for ‘Innovation developed through an NGO/Not-for-Profit Organisation (NPO) or Community Based Organisation (CBO)’. The award went to the Technology Research Activity Centre (TRAC) Programme of SET Education Support of the Department of Civil Engineering at the University of Stellenbosch.

TRAC South Africa is a national, non-profit programme, the objective of which is to support physical science, mathematics, and technology education in South African secondary schools. The TRAC Programme seeks to enable and encourage learners to enter into careers in science, engineering, and technology. TRAC is also involved in education intervention programmes, where the main aim is to uplift the standard of physical science education in South Africa. This is done with educator training programmes, vocational guidance assistance, as well as classroom intervention in schools where the resources are limited or lacking. The TRAC emblem has become a familiar hallmark in the endeavour to improve what is being done to enhance science and mathematics amongst school learners, especially in the rural areas. In 2006, in excess of 68 000 learners were exposed to the TRAC programme, while during 2007, 109 000 learners were exposed to the programme and 2 831 teachers were trained by TRAC.

Prof Fred Hugo, who served as SAICE president in 1993 and who is the ‘father’ of TRAC, received the award together with TRAC Executive Director, Debby Cromhout.

To Allyson and the TRAC team – please accept our heartiest congratulations!

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**Ever had a SMART idea that could change our world for the better and wondered what to do with it?** By thinking ahead you can use your innovative, SMART idea to resolve:

- Traffic congestion
- Water conservation
- Recycling issues
- Sustainable housing for healthy communities
- South Africa’s sanitation backlog
- Ergonomic challenges for women in construction, e.g. lightweight tools OR
- Have you designed a small SMART section of a workable project

Then you MUST enter the SAICE SMART Awards for 2008. Your SMART idea might be worth R20K.

All entries must comply with the SMART philosophy:

- sustainable
- magnificent thinking/innovation
- amazing solution
- right for the time and place
- truly and proudly Civils South Africa

For more information, contact Zina Girald on 27 (0) 11 805 5947 or zgirald@saice.org.za. You can also download the entry form on-line: http://www.civils.org.za/EventsAwards/Awards/SMARTablaid/117/Default.aspx

Entries close on 10 September 2008

Please note: The SMART Awards are awarded to individuals and not to projects.
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<td>The Application of Finite Element Method in Practice SAICEstr06/00018/08</td>
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<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<td>06–12 December Bedfordview</td>
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<td>17–19 September TBA</td>
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<td>6–8 October Midrand</td>
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<td>4–6 November Heidelberg</td>
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<td>2–4 December TBA</td>
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<tr>
<td>26–27 August Polokwane</td>
<td>Technical Report Writing</td>
<td>Les Wiggill</td>
<td>Sharon Mugeri <a href="mailto:cpd.sharon@saice.org.za">cpd.sharon@saice.org.za</a></td>
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<tr>
<td>27–29 August IIR House Rosebank</td>
<td>Practical Masterclass in Engineering Procurement &amp; Construction Management ProvSAICEot08/00316/08</td>
<td>Various presenters <a href="http://www.iir.co.za">www.iir.co.za</a></td>
<td>Carmen Spence <a href="mailto:csperience@iir.co.za">csperience@iir.co.za</a></td>
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<td>8–9 September TBA</td>
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<tr>
<td>23 September Howick, KwaZulu-Natal</td>
<td>Bulk Transport Optimisation symposium</td>
<td>Various presenters</td>
<td>Prof. Carel Bezuidenhout <a href="mailto:bezuidenhout@ukza.ac.za">bezuidenhout@ukza.ac.za</a> 033 260 5703</td>
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<tr>
<td>24–26 September Langebaan</td>
<td>SAICE Transportation Division Quadrennial</td>
<td>Various presenters</td>
<td>Carla de Jager <a href="mailto:info@carlamani.co.za">info@carlamani.co.za</a></td>
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<td>06–07 October Polokwane</td>
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<tr>
<td>13–14 October Port Elizabeth</td>
<td>Business Finances for Built Environmental Professionals SAICEfn06/00004/08</td>
<td>Wolf Weidemann</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<td>11–12 November Gauteng</td>
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<td>24–25 November Gauteng</td>
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<td>08–09 October Polokwane</td>
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<tr>
<td>15–16 October Port Elizabeth</td>
<td>Handling Projects in a Consulting Engineer’s Practice SAICEproj06/00003/08</td>
<td>Wolf Weidemann</td>
<td>Dawn Hermanus <a href="mailto:dhermanus@saice.org.za">dhermanus@saice.org.za</a></td>
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<td>06–07 November Gauteng</td>
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<td>22–24 October Gauteng</td>
<td>Annual Workshop on the newest version of USEPA SWMM5 and PCSWMM.NET SAICEwat06/00090/09</td>
<td>Professor William James &amp; Chris Brooker</td>
<td>Kathy Holland <a href="mailto:admin@computationalhydraulics.com">admin@computationalhydraulics.com</a></td>
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<td>29–31 October Durban</td>
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<td>12–14 November East London</td>
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<td>19–21 November Cape Town</td>
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<tr>
<td>27–31 October Gauteng</td>
<td>Tailings Course 2008 SAICEot07/00232/10</td>
<td>Beric Robinson</td>
<td><a href="mailto:bericr@fraseralexander.co.za">bericr@fraseralexander.co.za</a></td>
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<tr>
<td>24–26 November Cape Town</td>
<td>2nd International Conference on Concrete Repair, Rehabilitation and Retrofitting</td>
<td><a href="http://www.civil.uct.ac.za/iccr">www.civil.uct.ac.za/iccr</a></td>
<td><a href="mailto:iccr@eng.uct.ac.za">iccr@eng.uct.ac.za</a> +27 21 689 7471</td>
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