Development of best practice guidelines for water quality management in the South African mining industry

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Background

Mining can adversely affect water quality and poses a significant risk to South Africa's water resources. Proactive management of environmental impacts is required from the outset of mining activities in order to reduce this risk. Major strides have been made over the last 7 to 8 years, by both the Department of Water Affairs & Forestry (DWAF) and the mining industry, in developing strategies and management plans for the effective management of water within the industry. This has largely been achieved through the development of joint structures where problems have been discussed and addressed through cooperation. This process, which was started around 1991, has continued through to the present time.

The mining sector management strategy has been developed at a number of different levels as follows:

- A detailed *Management Plan*, that sets out strategic objectives, broad strategies and functional and organizational arrangements.
- *Operational Guidelines*, that define and document specific operational procedures.
- *Technical Guidelines*, that define and document best practices for pollution prevention and impact minimization from mining operations.

The Technical Guidelines consist of *Best Practice Guidelines* (BPGs) and *Regulations.*

Water management policy for mining and the role of best practice guidelines

The water management strategy for a mine must be implemented according to the following hierarchy of steps:

Step 1: Water quality management measures should be implemented at source. The fundamental principle is to prevent, inhibit, retard or stop the hydrological, chemical, microbiological, radio active or thermodynamic processes, which result in the contamination of the water environment, where the deterioration in water quality originate.

Step 2: If the water quality management measures at source do not prevent the discharge or disposal of water containing waste, reuse and minimization strategies should be implemented. Such measure may include partial treatment of water in order to make it suitable for reuse, the prevention of the inflow of ground and surface water into the mine, etc.

Step 3: If the water quality management measures at source and the reuse and minimization strategies do not prevent the discharge or disposal of water containing waste, water treatment strategies should be implemented.

Various of the measures taken as part of these three steps will be construed as a water use in terms of Section 21 of the National Water Act, 1998 (Act 36 of 1998), and the appropriate water use licence needs to be applied for.

Step 4: Where the measures to be taken in Steps 1 to 3 do not prevent the discharge of disposal of water containing waste in the short term, and the quality of the proposed discharge or disposal of water containing waste still exceeds the applicable waste water standard for the catchment or the water quality objectives specified by a catchment's Water Quality Management Plan, application may be made for a phased water use licence containing:

a) Extensive motivation for the water use licence, explaining financial, social as well as environmental implications of each proposed point of discharge or disposal.

b) Firm commitments with a time schedule for implementation of measures to achieve the water quality objectives for each specific point by either preventing the discharge or treatment to achieve the specified objectives. Studies and investigations are interim measures and not final commitments.

The disposal or discharge of water containing waste which exceed the applicable standards will only be considered as a last resort and as an interim measure. Such an application submitted to the Regional Director will be referred to the Chief Director: Water Use and Conservation and only if steps 1 to 3 have been implemented and if the impact of the proposed discharge or disposal is acceptable to the potentially affected water users.

The disposal or discharge of water containing waste, which exceeds the applicable standards, as described in Step 4, will not be applicable to new investment decisions but only historic situations will be considered for such a phased improvement.

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The BPGs for Water Quality Management in the Mining Industry will provide guidance on how to comply with steps 1 to 3 of this hierarchy.

The BPGs will also be used to draft water use licence conditions in cases of phased licences where compliance with steps 1 to 3 can not be demonstrated, and where the DWAF is prepared to issue a phased water use licence. The BPGs will not be enforced by regulation but rather through negotiation through the license process prescribed by the National Water Act, 1998 (Act 36 of 1998).

The BPGs will be used by:

- DWAF water quality management personnel as a basis for negotiation with the mining industry
- By the mining industry as a guideline of what the DWAF considers should be implemented at a mine.

Procedures for development of best practice guidelines

The DWAF has adopted an approach of broad based consultation in the development of these Best Practice Guidelines and representatives from the mining industry, other government departments and various specialists have been brought into the process. The consulting company of Pulles Howard & de Lange Incorporated (PHD) has been appointed to drive the process and prepare the first drafts of the BPGs for consideration and input by the other parties. The process of developing a BPG can be divided into different steps as described below.

- Preparation of the first draft BPG: background research is undertaken, information is collected, discussions are held with relevant persons and a draft BPG is prepared.
- Review of first draft BPG: the draft BPG is distributed to selected specialists within DWAF, the mining industry and/or consultants and a focused 1-day workshop is held where the draft BPG is critically reviewed and changes are agreed upon.
- Preparation of the second draft BPG: the first draft BPG is then updated to reflect the changes agreed upon during the specialist workshop and a second draft BPG is then prepared.
- BPG Workshop: the second draft BPG is then sent out for review to a wide range of interested parties and specialists within the mining industry. These specialists are identified and nominated by the industry and typically number about 20–30 persons per BPG. A one-day workshop is then held where the second draft BPG is discussed in detail and further changes to the BPG are defined and agreed upon.
- Preparation of the final draft BPG: the comments and changes agreed upon at the workshop are incorporated into a final draft BPG.
- The final draft BPG is submitted to the project Steering Committee and then to the Director: Water Quality Management for final approval.
- Issue of BPG: the approved BPG is then printed and distributed.

A comprehensive technology transfer strategy is also being developed in order to ensure that the BPGs are properly understood and applied by all parties. This strategy will be multi-faceted and will include the following components:

- Holding of focused hands-on training workshops in the different mining regions to ensure that DWAF and mining personnel understand the BPGs and how to use them.
- Holding of focused one-day conferences by the Mine Water Division of the Water Institute of Southern Africa where a variety of speakers will be invited to discuss the various topics of the BPGs.
- Provision of material to the mining industry for incorporation into its internal employee and management training programmes.
- Provision of material to tertiary training institutions such as universities and technikons for incorporation into their training programmes.
- Making the BPGs available in electronic format on a DWAF web page for downloading by interested parties.

Topics for best practice guidelines

It has been decided to develop the BPGs in a phased manner and to classify the BPGs into the following three broad categories:

- General BPGs focusing primarily on pollution prevention and water management strategies and tools.
- Water Treatment BPGs focusing primarily on treatment options for the various primary contaminants found in mine waters (acidity/ pH; arsenic; calcium and magnesium; chloride and sodium; cyanide; fluoride; boron; iron and manganese; other metals; micro organisms; nitrogen compounds; phosphates; radionuclides; sulphate; and suspended solids).
- Activity BPGs focusing primarily on prevention of water pollution from specific mining activities such as coal mine residue deposits; gold mine residue deposits; opencast coal mining pits/voids; opencast gold mining pits/voids; underground coal mining operations; underground gold mining operations; filling of sinkholes and subsidence; coal discard dumps reworking operations; gold slimes reclaiming operations; water pollution control dams at mines; informal mining practices.

It has been agreed that the priority BPGs are the General BPGs dealing with pollution prevention and water management strategies and tools. In particular, it has already been agreed that the priority BPGs (listed in order of decreasing priority) are the following:

BPG1. Water and salt balances
BPG2. Water monitoring systems
BPG3. Stormwater management
BPG4. Water Reclamation and Re-use
BPG5. Prediction and management of long-term impacts
BPG6. Selection of treatment and management options.

BPG1 on water and salt balances

The water and salt balance is considered the most fundamental building block and foundation of a mine water management system. Without an effective and accurate water and salt balance, it is not possible to ensure that the mine water management strategy is properly focused.

Water and salt balances can be used as a tool to:

- define and drive water management strategies
- audit water usage from various sources
- identify points of high water consumption or wastage
- identify and quantify imbalances
- locate and quantify sources of seepage and leakage
- identify and quantify pollution sources
- assist with the design of storage requirements and minimizing the risk of spillage
- simulate and evaluate various water management strategies before implementation
- assist in decision making.

Water and salt balances should be used as an ongoing water management tool and, for this reason, they should be updated on a regular basis, both in terms of adding new data and ensuring that the reticulation system reflects all changes that have been made. This requirement for updating should be borne in mind when selecting the approach to be used for the balances (manual system, spreadsheets, specialized computer balance software, etc.).

BPG2 on water monitoring systems

The development and maintenance of well designed and effective monitoring programmes are essential within any mine water management strategy on the basis that 'one cannot manage what one cannot measure'. This BPG deals with the following aspects of a monitoring strategy:

- definition of the objectives of a monitoring strategy
- design of a monitoring strategy (including both discrete and continuous monitoring)
- monitoring and sampling equipment and procedures
- procedures for implementation of monitoring programme
- data management systems
- audit and quality assurance of monitoring programme.

This BPG will be cross referenced to BPG 1 and BPG 5 which both have a strong requirement for data derived from well structured monitoring programmes.

BPG3 on stormwater management

The separation of clean and dirty water on mines is one of the most fundamental pollution prevention principles within the mine water management hierarchy. Although the principle is a very simple one, it is nevertheless often misapplied and this BPG will set clear guidelines on how to achieve it by focusing on the following:

- practical procedure to develop stormwater management plan
- define the content of a management system that will ensure compliance with the targets and objectives of the plan
- define where expertise of suitably qualified persons is required at the various stages of plan development, implementation and operation
- reference relevant legislative and policy issues that need to be considered in a stormwater management plan.

It is believed that proper application of this BPG will have major benefits to reducing pollution and reducing water demand on South African mines. It will also make a major contribution to optimising water reclamation strategies as addressed in BPG4.

BPG4 on water reclamation and reuse

The development of appropriate water reclamation strategies is one of the fundamental components of an integrated mine water management strategy. Water reclamation and re-use is also a high risk activity if it is not carried out according to a well defined procedure that includes the following steps:

- Identification of all sources of water quality deterioration on a mine.
- Identification of all water users on a mine with detailed specification of the water quantity and quality requirements (this process essentially entails the definition of the worst possible water quality that a user can tolerate without suffering unacceptable water quality related effects and requires a clear knowledge of the consequences for each user of different water qualities).
- Delineation of all physical features of a mine's water reticulation system including tanks, dams, pumps and pipeline capacities.
- Optimization process to evaluate all the above data, together with water treatment requirements in order to define the most appropriate and cost effective water reclamation strategy.

The development and implementation of inappropriate water reclamation strategies can have very severe consequences for a mine in terms of effects such as corrosion, scaling, reduced recovery efficiencies, reduced security of supply, etc. and this BPG will aim to assist in ensuring that the risk of encountering these negative consequences is minimized.

BPG5 on prediction and management of long-term impacts

The need to confidently predict mine water quality into the future and, in particular, to understand and quantify the long term water quality consequences of management decisions, is a key requirement both for operational mine water management and also for mine closure. This is an issue that has been historically neglected in South Africa, primarily due to the lack of suitable tools for making such predictions and, perhaps more importantly, the lack of guidance and agreement on which tools are acceptable.

This is a topic that has been enjoying a lot of debate in South Africa recently and this BPG will address the following aspects:

- Sampling and analytical techniques to provide data for prediction purposes.
- Use of static and kinetic laboratory tests to generate data.
- Definition of appropriate types of geochemical models to be used (where and when to use kinetic and equilibrium models).
- Definition of support models to be used for geochemical prediction.
- Verification and calibration of models.

This BPG is viewed as a particularly critical one as the current practice in South Africa is inconsistent with many mines applying inappropriate models or assessment techniques, leading to conclusions that may be either patently wrong or which have low confidence attached. This situation results in a risk of wrong management decisions being made and a risk that mine closure will never be granted.

BPG6 on broad guidelines for selection of water treatment technologies

Whereas a whole series of BPGs is planned to cover water treatment issues in some detail, a need has been defined for a BPG that assists mines in identifying the nature of their problem and the appropriate types of water treatment technologies that they should be considering. The detail on the different types of water treatment will be covered in the focused water treatment BPGs and this BPG6 will refer users to the more detailed BPGs. This BPG will aim to assist the mines in taking a holistic view when identifying suitable water treatment technologies and will also present a rigorous selection procedure (presented in the form of a flowchart) that should be followed to ensure that appropriate and cost-effective technology options are identified.

Conclusions

The production of the envisaged series of BPGs is viewed as a major positive development in the management of the impact of mining on the national water resource. Primary benefits will include the following:

- Consistency in the approach of the DWAF from mine to mine and region to region.
- Clarity on what actions need to be taken by mines to satisfy DWAF that pollution prevention, water reclamation and treatment aspects have been correctly applied.
- Uniformity in general water use licence conditions.

These BPGs are also considered to be a unique feature to South Africa. Whereas Australia has issued a series of Best Management Practices for mining, these tend to more generic and philosophical in nature than will be the case with the South African BPGs. Whereas the BPGs will also draw on relevant experiences elsewhere in the world, it is also envisaged that they will, in time, serve as a useful example to be emulated in other mining countries around the world. ◆

BacTech/Mintek enter alliance to commercialize base metal bioleach technology*

BacTech Metallurgical Solutions Ltd (BacTech) and Mintek have executed a Memorandum of Understanding with Industrias Peñoles S.A. de C.V. of Mexico: to commercialize base-metal bioleach technology. The definitive agreements are due for completion within three months.

Peñoles' funding commitment to the development programme is between US$ 4.4 million and US$ 5,4 million.

Peñoles is one of Mexico's largest natural resource/industrial groups. It operates the largest non-ferrous metals complex in Latin America, and the fourth-largest in the world. It is also the world's largest producer of refined silver and a significant producer of lead, zinc and gold.

One of the major benefits of the bioleaching route for copper production is that conventional downstream technologies, such as solvent extraction and electrowinning, can be used to produce metals on site, in preference to shipping concentrates to smelters. Other advantages of the process, compared with smelting and pressure leaching, are:

- simplicity and ease of operation
- lower capital and operating costs
- environmentally acceptable waste products. ◆

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