# MINE WATER RECLAMATION AND RE-USE - SOUTH AFRICAN EXPERIENCE


**ANDRE M VAN NIEKERK**

Golder Associates Africa, PO Box 6001, Halfway House, 1685, South Africa;
E-mail: amvanniekerk@golder.co.za



## ABSTRACT

Mine water management in South Arica has evolved over the last 20 years from simply dealing with a pollution issue to recognizing mine water as a valuable resource. The typical hierarchy of mine water management is reflected in Figure 1:

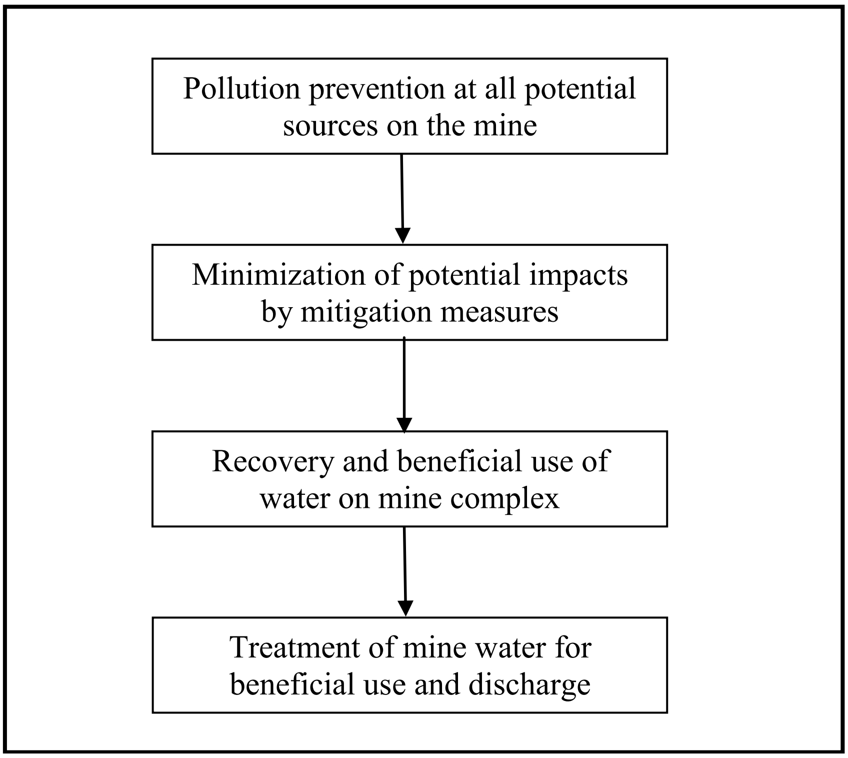


Figure 1. Hierarchy of Mine Water Management

Water reclamation and re-use must always be developed and implemented in an integrated manner with the other water management actions on a mine.

A number of mining, environmental and water related drivers have in the past 5 years resulted in the implementation of mine water reclamation and re-use projects. South Africa is one of the first countries to implement on commercial scale, mine water to potable water reclamation project. This paper reviews the recent developments which precipitated these projects.


## 1. WATER RESOURCES CONTEXT

Water resources are unevenly spread across South Africa and the overlay of water resources and mining resources indicates that:

- large mining operations are present in several of the nationally important water management areas, including the Vaal, Olifants, Mkuzi, Crocodile and Mhlatuzi;
- some mining operations are located at the vulnerable headwaters of the catchment, where mining impacts could cascade down the river system and be felt far down-stream. An example is the Highveld Coalfields located in the upper Olifants River;


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- mining and associated minerals processes can impact a catchment in a number of different ways ranging from:
  - pollution emissions to rivers and wetlands;
  - changes in land use patterns which impact on reliable yield;
  - draw on limited available water resources; and
  - changes to the groundwater resources depending on the type of mining.

However, in general, the available water resources on the mining associated catchments are fully, if not over allocated. The need for augmentation of available water is abundantly clear when considering the following:

- Vaal River is already augmented from the Tugela River, Usutu River and Lesotho Highlands Project; and
- Olifants River is extensively augmented from Komati, Usutu and Vaal to supply power generation requirements.

Some communities in such catchments have to consider new and alternative water resources. The towns located in the Upper Olifants River Catchment are examples. The current and projected future water requirements for Witbank are contrasted to the safe yield from the Witbank Dam as illustrated in Figure 2.

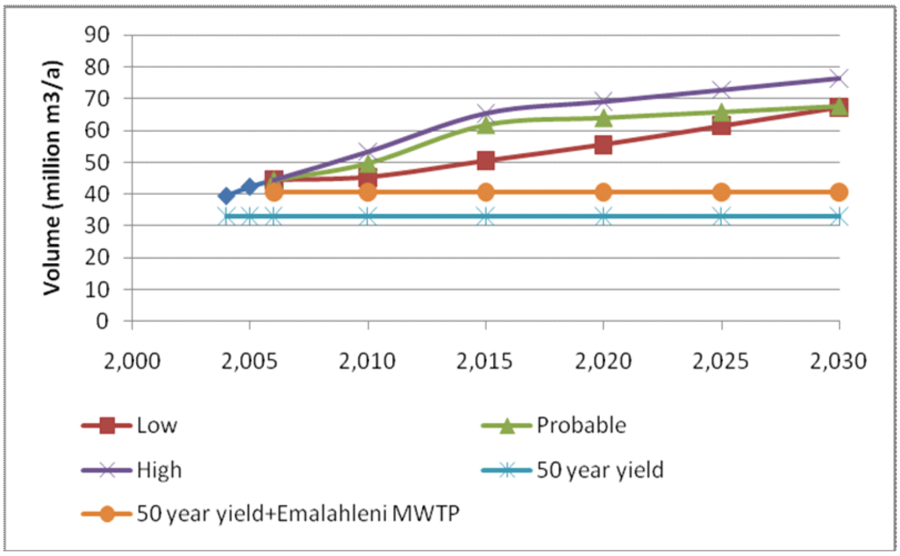


Figure 2. eMalahleni Water Requirements and Available Water Resources.

In the catchment water resources context, mine water can be reclaimed for any of the following users:

- municipal and potable;
- industrial operations;
- new mining ventures;
- support of aquatic ecosystems and wetlands; and
- agriculture.

## 2. MINE WATER AS A RESOURCE

In several catchments, substantial water resources are stored in old and active mine workings. This water is typically continuously recharged from surface and represents the potentially available water resource.

To place this in context, consider the following information related to the Upper Olifants River Catchment:

- mine water stored in the Highveld Coalfields = 522 million $m^3$;
- combined storage capacity of Witbank Dam, Middelburg Dam and Loskop Dam = 514 million $m^3$.

In the Witwatersrand Goldfields, as another example, the potential mine water storage volumes are as follows:

- West Rand Basin (full) = 43.3 million $m^3$
- Central Rand Basin (filling) = 213.0 million $m^3$
- East Rand Basin (filling) = 400.4 million $m^3$

Compare these storage volumes to the capacity of the Vaal Dam at 2 536 million $m^3$.

The realization has now grown that impacted mine water is a potential source of water in the Olifants River catchment. The Department of Water and Environmental Affairs project on Upper Olifants River Catchment Water Resources Management states that mine water reclamation and re-use is a preferred option to support further growth in the communities of the upper Olifants River.

The main drivers in the development of mine water as a resources include the following:

- mining companies taking responsibility for the impacts on the water environment and associated long term liabilities;
- the realization that in many cases, eventual mine closure is driven by the ability to deal with long term post mining impacts on the water environment;
- regulatory pressures and the linkage of mining licenses to the ability to deal with mine water aspects;
- water requirements by neighbouring communities, industrial operations and other (especially new) mining operations; and
- the value of water, as reflected by the price of water. The price of water has escalated substantially over the past decade as reflected by some indicative price ranges:
  - Vaal River raw water = R2.60/$m^3$.
  - VRESSAP project = R4-5/$m^3$.
  - Water supply to Lepalale Region = R15 – 20 $m^3$.

## 3. COMPONENTS OF A MINE WATER RECLAMATION PROJECT

The key physical infrastructure components of a mine water reclamation project include:

- mine water abstraction from mine workings;
- mine water conveyance to a treatment plant;
- product reclaimed water storage;
- product / reclaimed water distribution and delivery to end users; and
- waste handling and disposal.

The different mine water reclamation scheme physical infrastructure components are reflected in Figure 3.

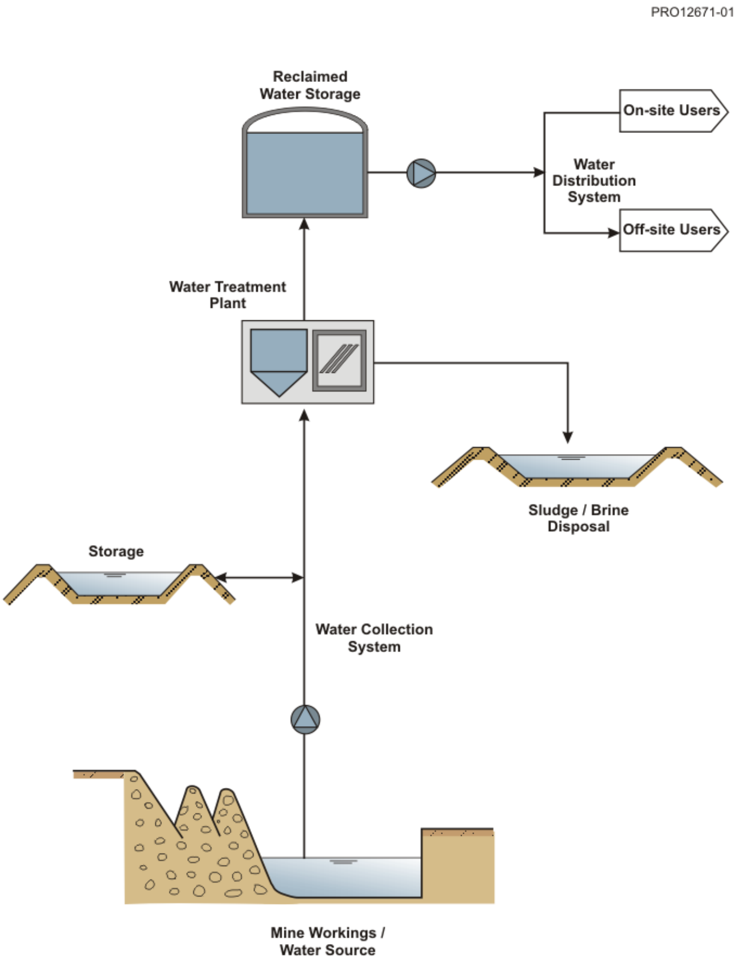


Figure 3. Mine Water Reclamation Project Infrastructure Components

## 4. KEY SUCCESS FACTORS

The South African experience over the recent years indicated a number of key success factors in mine water reclamation and re-use. Figure 4 reflects these identified key success factors:

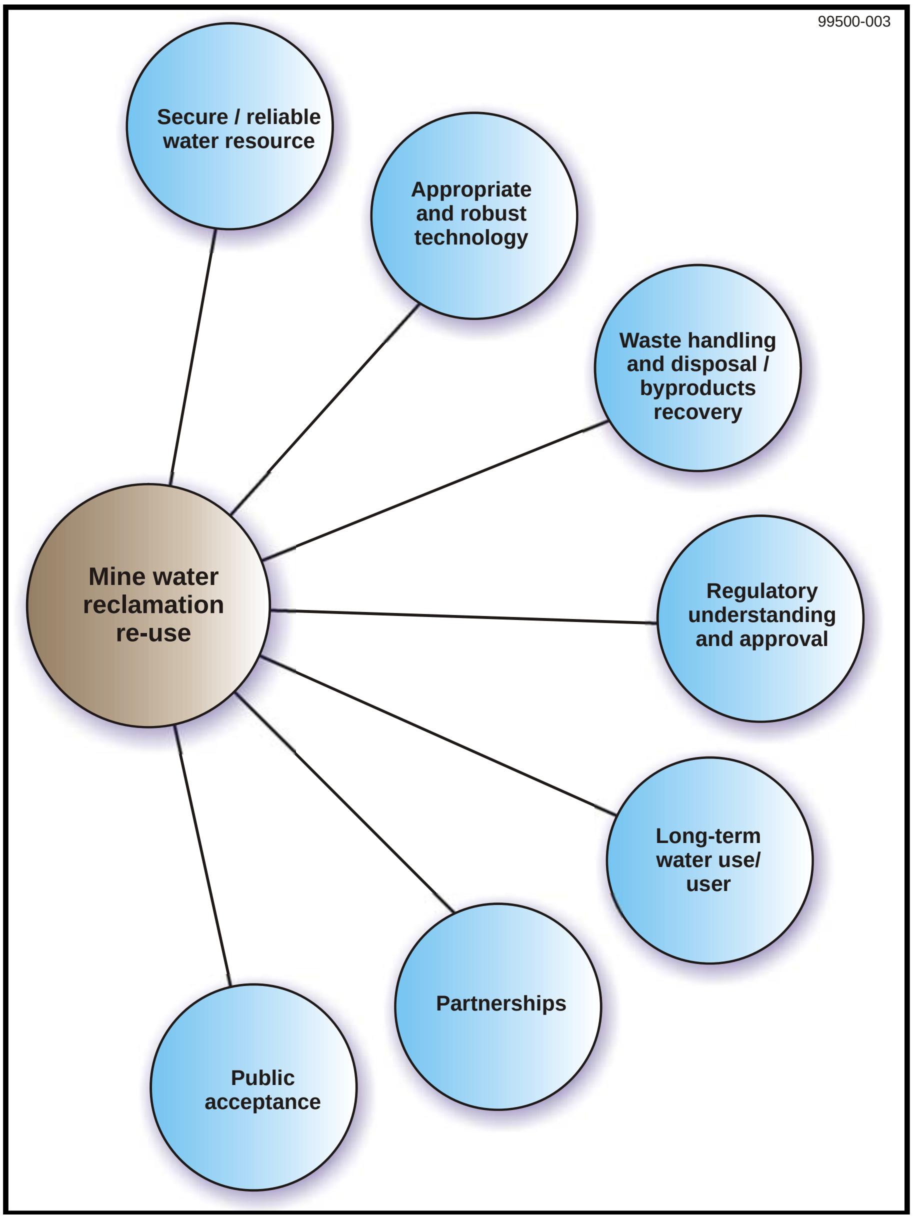


Figure 4. Identified Key Success Factors

### Secure and Reliable Water Re-Source

In essence, the mine water resource being exploited for such projects arises from the modification of natural surface water groundwater by mining. Like all natural water resources, it is subject to cyclic, climatic and specifically rainfall conditions. Characterizations of the mine water resource in terms of value and quality is therefore important based on:

- understanding of the hydrological and hydrogeological phenomena which result in the mine water quality; and
- geochemical resources which determine the mine water quality.

This requires substantial fieldwork, use of sophisticated water simulation models, calibration of the model and prediction on long term sustainable yield of mine water.

The available mine water may vary over time depending on:

- climatic conditions;
- available underground storage; and
- dynamic mining plans on active operations.

The Water Research Commission, Department Minerals Research and mining companies have invested substantial effort over the last decades to conceptually understand, quantify and predict mine water systems. Without a confident statement on the long term availability of mine water, a reclamation and re-use project cannot proceed.

**Appropriate and Reliable Treatment Technology**

Mine waters are characterised by high acidity, high metals, high salinity and in some cases specific pollutants such as radio-nuclides.

Much research effort has again been mobilized to find appropriate and reliable treatment technologies. The mining industry in collaboration with technology suppliers have piloted and demonstrated a wide spectrum of technologies including:

- membrane based NF/RO treatment;
- precipitated processes such as Savmin and the CSIR’s barium carbonate process;
- ion exchange, such as Gypsix process;
- passive treatment using renewable carbon sources for sulphate removal; and
- biological treatment involving sulphate removal and sulphur recovery.

Key considerations to the selection of appropriate and reliable treatment technologies are:

- proven performance;
- energy usage and associated carbon footprint;
- capital cost;
- operations and maintenance cost;
- ease of operations;
- robust processes able to deal with fluctuating water flow/quality;
- waste generation;
- water recovery; and
- reliance on imported components and chemicals.

The South African projects have a choice of treatment technologies and there is no single technology which will satisfy all the diverse project requirements. Figure 5 illustrates the full spectrum of available mine water treatment technologies. While may of these treatment technologies have been proven on full-scale facilities, some of the technologies still require industrial scale verification.

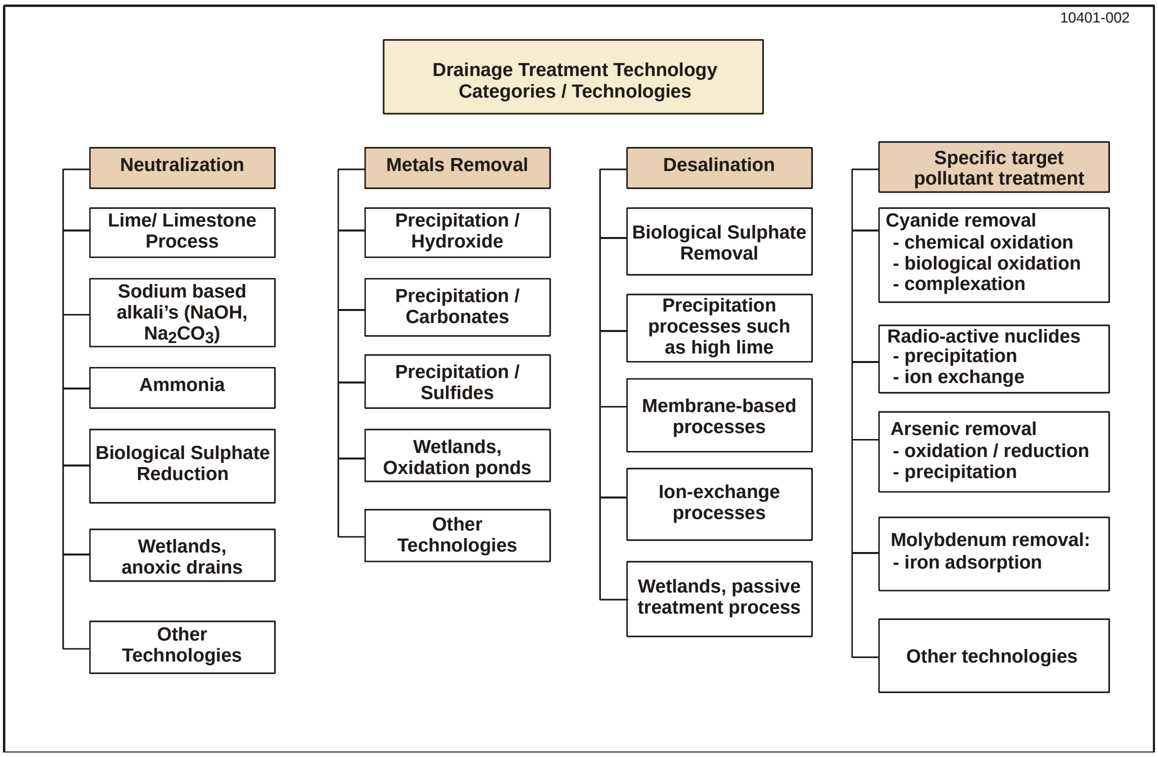


Figure 5. Generic Range of Drainage Treatment Technologies

## Waste Handling and Disposal

Mine water treatment will produce a waste product typically containing:

- some metals, specifically Fe, Aℓ, Mn;
- $Ca\text{-}Mg\text{-}SO_4$ salts; and
- diverse other compounds.

Waste generation must be carefully and accurately quantified in terms of volume and composition. Waste disposal is regulated in terms of the New National Environmental Management: Waste Act, Act 59 of 2009. The regulations in terms of this Act for waste disposal are onerous and capital intensive to construct and maintain.

Waste management and disposal are key considerations related to water treatment technology selection, mainly due to the capital investment and long term liabilities associated with waste.

This background provided an initiative to minimise waste and to recover some saleable byproducts. The field of selective byproducts recovery is now actually re-searched and the following attractive candidate byproducts recovery:

- Membrane desalination technology – gypsum byproducts for the building components industry;
- Barium sulphate removal technology – sulphur byproduct; and
- Ion exchange technology – various potential fertilizer and plant growth stimulant byproducts.

## Regulatory Understanding and Approval

The water, environmental and mining sectors have relatively new enabling legislation and associated regulations. The mine water reclamation projects pose a challenge to the integration of the regulatory approval process associated with:

- Mineral and Petroleum Resources Development Act , Act 28 of 2002;
- New Water Act, Act 36 of 1998;
- Water Service Act;
- National Environmental Management Act, Act 107 of 1998;
- National Environmental Management : Waste Act, Act 59 of 2008.

Apart from these key regulatory processes, other related regulatory requirements may also apply. These relate to:

- SA National Heritage Resources Council;
- National Nuclear Regulator;
- Occupational health & Safety Act, as it relates to Major Hazard Installations;
- Mines Health and Safety Act as it relates to project implementation; and
- Various laws and regulations related to land use, servitudes etc.

It is a key success factor to mobilize and engage the different regulatory authorities in an integrated and coherent process, underpinned by a public participation and key stakeholder consultation process. **Figure 6** illustrates a simplified regulatory approval process diagram, reflecting some of the interconnections between the parallel processes.

## Long Term Water Use Agreement

Mine water reclamation and re-use projects require substantial capital investment and long term operation and maintenance. A long term water use agreement by a stable and reliable water user is a key success factor.

The first South African mine water reclamation and re-use projects were implemented on the premise of supplying potable quality water to water services authorities (typically Local or Regional Municipality) and/or other bulk water services processors, such as a Water Board.

The Water Services Act, Municipal Finance Management Act and Municipal Structures Act all contain requirements for such long term water supply agreements. The situation is further complicated by the fact that such water reclamation and supply schemes are seen as unsolicited offers to provide a municipal or community service.

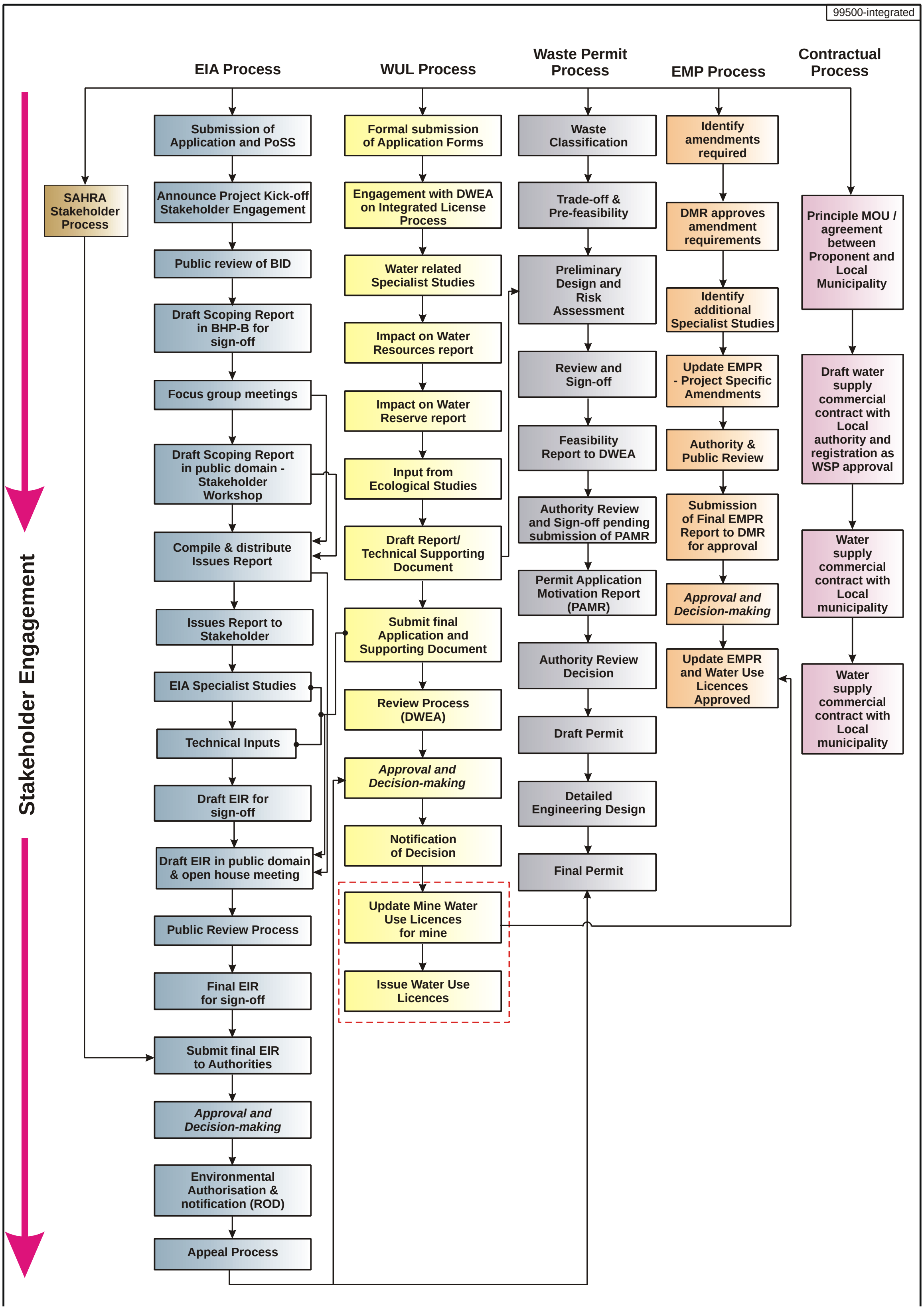


Figure 6. Schematic of Integrated Regulatory Processes

From the perspectives of cities and towns entering into such water supply agreements, the key considerations are:

- access to a reliable source of water;
- support in fulfilment of their mandate and responsibility to provide water services;
- partnering with a private sector company which typically has capacity and resources;
- price of water at a competitive rate and linked to escalated adjustment dictated by the municipal services sector; and
- stimulus for growth and development, since water is a scarce resource to many areas.

## Partnerships

The implementation and operation of mine water reclamation requires several participants including:

- several mining companies may be involved since the scale benefits of regional schemes are significant. Collaboration between neighbouring mining companies has benefits in terms of collective use of infrastructure, cost benefits of larger schemes, inherent stability of having access to different mine water sources etc. The Department of Mineral Resources also support a regional approach so such schemes since it will underpin the department’s stated policy of developing and implementing regional mine closure;
- one of the participating mines may have to be the lead project proponent;
- the Department of Water and Environmental Affairs has also in the past issued directives to clusters of mines to collectively resolve their mine water management;
- specialist companies may be involved in the recovery and marketing of byproducts;
- water users have a vested interest in the success and long term stability of the mine water reclamation and re-use projects.

The spectrum of participants to such project opens up some future potential to explore:

- public private partnership;
- regional mine water companies; and
- other innovative institutional arrangements.

## Public Acceptance

The South African public is empowered by our democratic dispensation to actively participate and influence decision making on such projects. Many issues are typically raised by the interested and affected parties on such project, ranging from political to technical aspects, including:

- how safe is the reclaimed water, how quickly will it be guaranteed, is there a risk of residual radioactivity;
- are the mines escaping their responsibilities in terms of the principle of ‘Polluter Keys”, by implementing such projects? Will the water users effectively subsidise the mines;
- can such a project be socially just, for example where the reclaimed water is supplied to poorer neighbourhoods in a city or town, how many job opportunities are created;
- can the mines actually sell water, since the State and no private company is the custodian of the national water resources;
- what happens to such schemes when the mines close down, what post mining assurances are there to sustain the project.

Any mine water reclamation project must therefore be supported by an open and transparent public and stakeholder participation process. It is essential to have public support for such projects to succeed over the long term.

# 5. CONCLUDING COMMENTS ON SUSTAINABILITY

The long term sustainability of mine water reclamation projects can be summarised using the three pillars of the concept:

- Technical/financial aspects:
  - retention of competent and adequate staff resources to operate these schemes;
  - periodic confirmation of the mine water resources available;
  - fair and reasonable pricing of water;
  - financial resources to undertake the capitol replacement over time;
  - progressive optimization and refinement of treatment technology;
  - converting waste into saleable byproducts.

- Environmental aspects:
  - continuous improvement in terms of emissions to the environment;
  - energy efficiency;
  - reduction in carbon foot print.
- Social and regulatory aspects:
  - enabling legislation and associated regulations that support such projects;
  - public/private partnerships to augment the challenges in terms of public sector capacity;
  - institutional arrangements to provide continuity beyond mine closure.