Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage associated with the East, Central and West Rand Underground Mining Basins, Gauteng Province.

AMD FS LTS

newsletter

Edition 1 • July 2012

This newsletter provides information to stakeholders on the progress of the feasibility study for a long-term solution to address the acid mine drainage associated with the Witwatersrand underground mining basins.

In January 2012, the Department of Water Affairs (DWA) initiated a feasibility study for the long-term solution. A multi-disciplinary team of consultants led by Aurecon SA in association with SRK Consulting and Turner and Townsend, and supported by specialists from different institutions was appointed to conduct the feasibility study.

The study is a planning study and forms a component of the bigger picture to address the AMD challenge. It is therefore one of several parallel initiatives such as the short-term interventions, monitoring of the underground mining basins, ingress studies and others.

This is the first newsletter on the feasibility study, and stakeholders will receive further newsletters at key milestones in the study.

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For more information on the feasibility study, please visit the AMD webpage on the Department of Water Affairs website:

http://www.dwa.gov.za/Projects/AMDFSLTS

water affairs
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Background and overview of the AMD challenge

Gold Mining on the Witwatersrand has taken place since 1886 (more than 120 years). Water in the underground mine workings was pumped to surface to enable mining to take place.

Positive consequences:

- Economic growth in Witwatersrand area and South Africa (taxes to State, jobs, wealth creation, etc.);
- Social growth, infrastructure development, urban development, industrial development; and
- Other

Negative consequences:

- When mining stopped, so did the pumping of underground mine water and mine voids started filling up with water;
- On contact with oxygen and water; the sulphide minerals such as Pyrite in the underground rock formed acid mine drainage (AMD);
- AMD then eventually decanted from the underground workings since 2002 from the Western Basin, and may decant in the Eastern and Central Basins in the absence of appropriate intervention; and
- Contribution to salinisation of major river systems threatens continued water supply security.

The challenge:

- Increasing water demand due to urbanisation trends and economic development;
- Threat to surface water and/or groundwater quality:
- Increasing salt loading on the Vaal River System; and
- Increased water demand from the Vaal Dam to dilute high salt concentrations in the Vaal River System.
- Etc.

Potential consequences:

- Deteriorated aquatic ecosystem health;
- Possible water shortages, which may lead to water restrictions that can have significant social, environmental and economic implications;
- Externalised cost to downstream users; and
- Commissioning of the next Vaal augmentation scheme to be brought forward.
- Etc.

Government initiatives to address AMD and water management challenges

DWA Planning Studies:

- Large Bulk Water Supply Reconciliation Strategies; and
- Integrated Water Quality Management Strategy.

Vaal River Strategy:

- Eradicate unlawful water use;
- Reduce water use by 15% through Water Conservation/Water Demand Management;
- Augment water supply through a further phase of Lesotho Highlands Water Project
- Establish a Strategy Steering Committee to facilitate co-ordination of the Strategy implementation;
- Re-use treated effluent (underground mine water return-flows by 2014/15)
- Plan yield replacement scheme in the Orange River by 2035;
- Manage uncertainties in the Crocodile (West) and Olifants Systems.

Cabinet appointed an Inter Ministerial Committee (IMC) to address the AMD challenges in the Witwatersrand Goldfields area.

IMC appointed a Team of Experts to investigate AMD issues. The team identified a number of interventions.

Recommendations to manage salinity in the Vaal River System and ensure water supply to downstream users, requires:

- An increase in dilution releases, until long-term solution is in place;
- Direct re-use of treated AMD; and
- Undertake pre-feasibility and/ or feasibility studies to investigate and recommend a feasible solution to address the AMD challenge in the long-term.

Team of Experts report recommended:

- **Short-Term Intervention -** pump water from the Western, Central and Eastern Basins to prevent surface decant. AMD will then be treated to correct the pH (neutralised) and to remove heavy metals before being discharged to surface water resources/river systems; and
- **Long-Term Intervention -** treatment as described above plus removal of salts, and consideration of alternative discharge/use options.
- Determine feasibility of an environmental levy
- Undertake further research to optimise sustainable solutions in the long term
- Implementation of ingress control measures
- Update monitoring infrastructure and programmes

Pre-feasibility and feasibility study for the long-term solution (this study)
A planning study commenced in January 2012 and is expected to be completed over a 13-month period, in February 2013.

Implementation of short-term interventions
Currently underway on authority of a directive issued by the Minister of Water and Environmental Affairs to the Trans-Caledon Tunnel Authority (TCTA).

Monitoring committee established

Implementation of ingress control measures underway

Research projects: other studies e.g. by CSIR and CGS underway

Terminology, facts and concepts explained

What is AMD?

AMD is produced when sulphate bearing minerals, found in all reefs mined for gold, are exposed to oxygen. The process, termed pyrite oxidation, is enhanced when water moves through and over the surfaces of acid bearing rock, which have been exposed due to mining activities having disturbed the underlying geology.

AMD is generally characterised by one or more of the following: low pH, high Total Dissolved Solids (TDS), high Sulphates (SO_4), and/ or high levels of heavy metals - particularly Iron (Fe) giving it the orange red colour, Manganese (Mn), Nickel (Ni) and/ or Cobalt (Co).

Typical colour of river polluted with AMD

What are salts?

In chemistry, salts are ionic compounds that result from the neutralization reaction of an acid and a base. They are composed of cations (positively charged ions) and anions (negative ions) so that the product is electrically neutral (without a net charge). These component ions can be inorganic such as chloride (Cl^-), as well as organic such as acetate ($CH3COO^-$) and monatomic ions such as fluoride (F^-), as well as polyatomic ions such as sulfate (SO_4^{2-}). There are several varieties of salts. Salts that hydrolyze to produce hydroxide ions when dissolved in water are basic salts and salts that hydrolyze to produce hydronium ions in water are acidic salts. Neutral salts are those that are neither acid nor basic salts. The main component of salinity in water associated with mining activities is usually Sulphate (SO_4). Salt concentrations in water can be measured as electrical conductivity (EC) in millisiemens per meter (mslm) or as Total Dissolved Solids (TDS) in milligrams per litre (mg/ℓ).

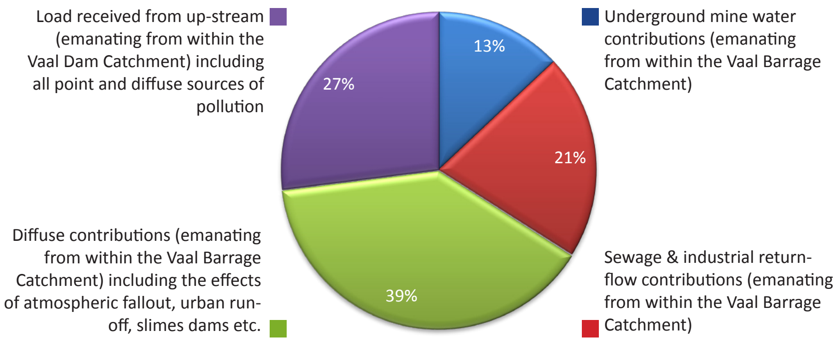
High salt loads have an effect on the fitness for the use of water for the irrigation of sensitive crops and can also affect the aquatic ecosystem and the suitability of water for drinking purposes.

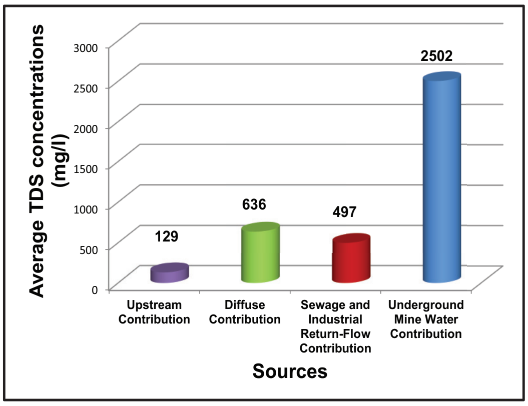
Vaal River Strategy

The Vaal River System supplies water to approximately 60% of the national economy and 45% of South Africa's population. The Vaal River Strategy was developed to ensure that sufficient water of good quality is available to supply the future requirements of this important area.

Where do the high salt loads in the Vaal River System come from?

The approximated load contributions in TDS received in the Vaal Barrage reservoir under a "Short-Term Intervention" scenario, i.e. pumping and semi-treatment without salts removal (based on historic data: October 1995 to September 2004) is as follows:





Note that although the percentage contribution of salts from mining is the lowest, the actual contribution in terms of salt concentration, is the highest.

Apart from applying source controls and addressing diffuse sources of salts through the applications of best practice and other measures, return flows will have to be re-used in future. The re-use of underground mine water has been prioritised since it contains the largest concentration of salts and since the removal of salts from this source would yield the biggest and quickest gains.

It is important to remove the salts from the Vaal System to ensure fitness of use of the Vaal River water further downstream, where the Resource Water Quality Objective has been set at 600 mg/ℓ TDS.

Terminology, facts and concepts explained

Integrated Water Quality Management Strategy for the Vaal River System

In the short-term the Integrated Water Quality Management Strategy allows for the following:

- Release of semi-treated AMD to the Vaal River system after neutralisation and metals removal;
- Dilution releases required from Vaal Dam to comply with the 600 mg/ℓ TDS operating rule set for the Vaal Barrage; and
- “Dilution water” used downstream of the Vaal Barrage.

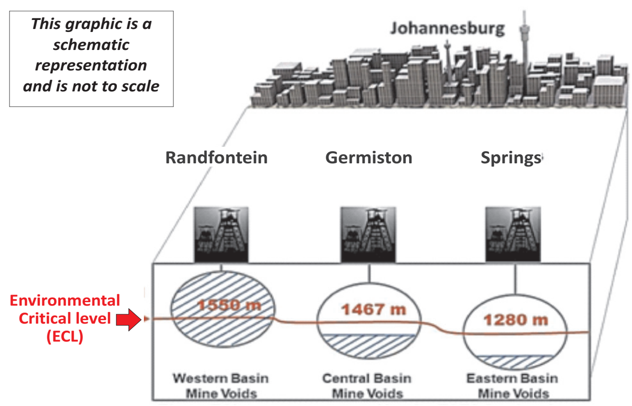
This short-term scenario will however not be sustainable in the long run. In the long-term population growth and the expected associated increase in salt-loading, inter-alia, due to the return flows from the wastewater treatment works that are steadily increasing over time, will require more and more dam water to be released. Excess “dilution” releases will build up in the lower Vaal in Bloemhof Dam, potentially externalising the elevated salinity levels to the lower Orange River, when Bloemhof Dam starts to spill. The removal of the salts from the AMD will prevent the use of water for dilution purposes and thus “save” a substantial amount of good quality water in the Vaal System. This will in turn contribute to ensuring water security in the Vaal water supply area.

What is an Environmental Critical Level (ECL)?

The ECL is defined as the shallowest level to which water can be allowed to rise in a flooded mine void before damage may occur to specific environmental features, including groundwater resources such as dolomitic aquifers in the study area.
The ECLs in the different basins have been set at levels which will ensure protection of both ground and surface water resources, including buffer zones. The levels currently being used to guide DWA management can be regarded as conservative estimates of the ECLs for each basin and can possibly in future be adjusted when more information becomes available.

What is a Socio-economic Critical Level (SECL)?

The SECL is the water level in the mine void above which the water in the void must not be allowed to rise, to protect specific social or economic features, such as Gold Reef City museum and active or planned mining.



These ECL’s are as proposed by the TCTA for the short-term intervention, but will be reviewed in the light of the feasibility study for a long-term solution

Feedback on short-term AMD interventions

Aims of the Immediate and Short-Term Interventions

The immediate and short-term interventions are designed to:

- Stop the uncontrolled decant that is occurring in the Western Basin and draw the water level down to the Environmental Critical Level (ECL); and
- in the Eastern and Central Basins prevent the ECLs from being breached.

A consequence of the ECLs being breached is the need to install larger pumping capacity and treatment works to be able to draw the water levels down again.

Progress on the Immediate and Short-Term Interventions

In the Western Basin the immediate intervention that was made to prevent untreated AMD decanting into the environment was to re-commission 2 of the treatment trains in the existing Rand Uranium water treatment plant. These would operate alongside the existing operating treatment train.
The Trans-Caledon Tunnel Authority (TCTA) is in the final stages of commissioning the recently completed upgrade and is very satisfied with the functioning and the related water quality. The two newly upgraded treatment trains are treating around 14 megalitres per day (Ml/d) and TCTA is in the process to increase treatment capacity to 25Ml/d.
The combined capacity of all three treatment trains is between 30Ml/d and 34 Ml/d, depending on the incoming water quality. Once this is achieved, the combined capacity of the plant will exceed the current decant by between zero and 8 Ml/d, which if the dry season continues will allow some drawdown in the mine void, and allow DWA to create a buffer against future high rainfall events.
On the short-term intervention the tender evaluation is complete and it is expected that the tender will be awarded in due course. The contract is structured in such a manner that award can be made in part or in full depending on the amount of funding available.

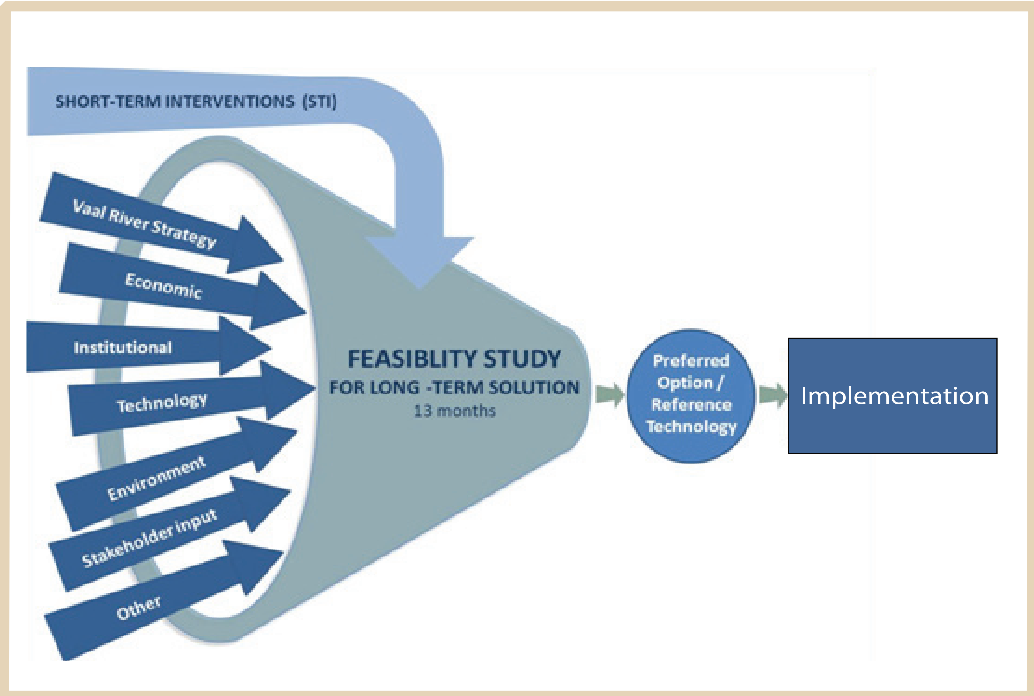
The TCTA is implementing “Emergency Water Works Management”, as part of immediate and short-term interventions, on authority of a directive issued on 6 April 2011 by the Minister of Water and Environmental Affairs.

Feasibility study for the long-term solution

Why is it necessary to do a feasibility study?

Nothing beats good planning - if you fail to plan, you plan to fail. There are several potential solutions that must be considered to address the AMD issue in the long-term. The aim of the feasibility study is to find the most cost effective solution/combination of solutions that are environmentally sustainable, technically sound, economically viable and institutionally feasible, in the best interest of the public. This is a very complex process and requires careful analysis of each option for all the different criteria.

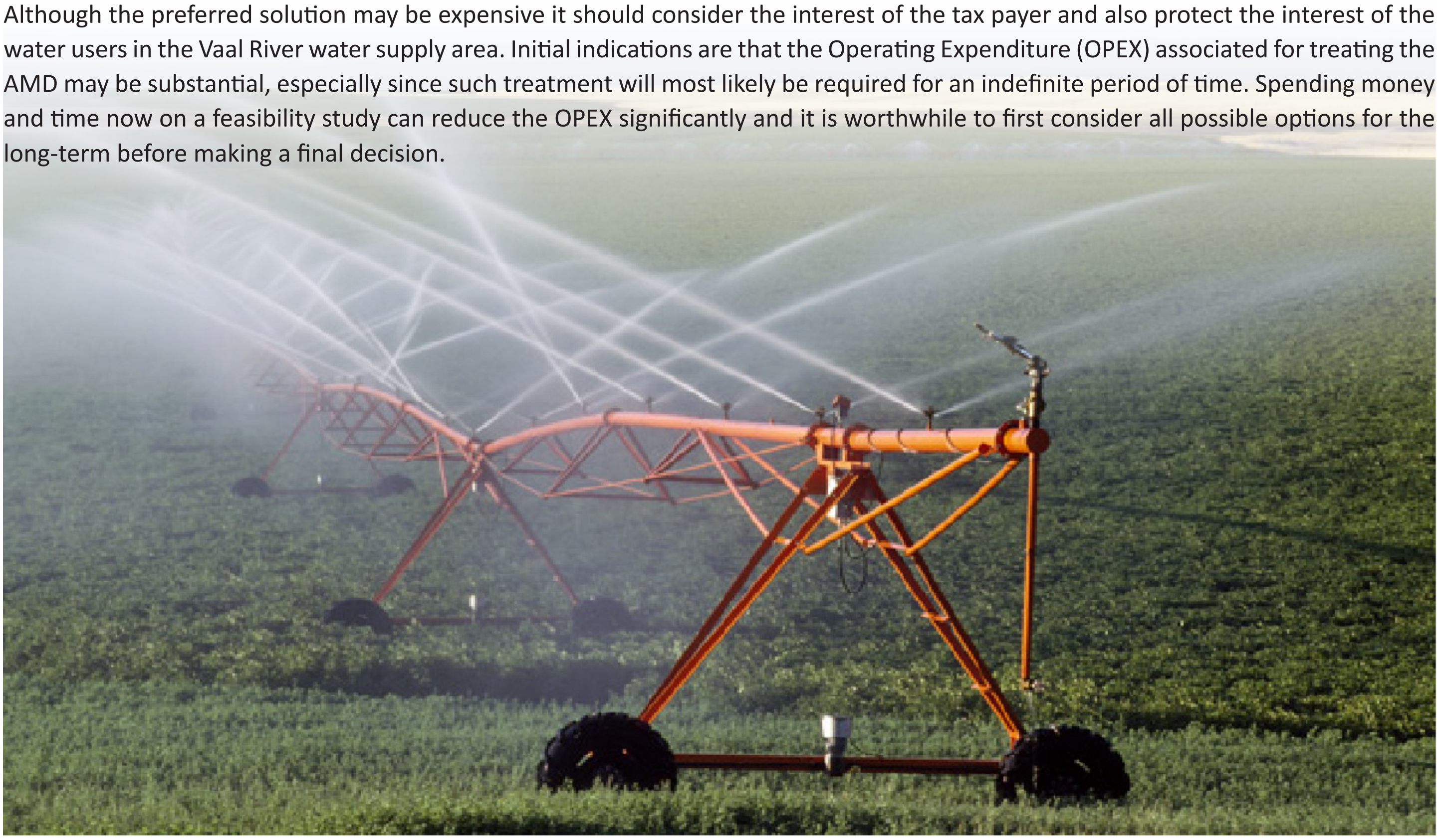
What is most important is that Government takes action, and does so fast – hence the proposed fast track process (see page 5). But, whatever solution is implemented, it must be defendable. The study aims to provide a sound basis for why certain decisions will be made and why some options will be discarded.



The figure shows that in addition to the short-term intervention that feeds into the long-term solution, there are several other aspects that must also be considered when conducting the feasibility study. The study will take all of these aspects into account when evaluating alternative options and "filter" the options using certain criteria. From the evaluation process a preferred option / reference technology may be formulated which will be used to compile the Request for Proposals.

One of the unfortunate by-products of AMD treatment is the considerable amount of waste that may be generated. Within the above filtering process the study will therefore not only look at technological options for treating AMD but will also look at options for minimising and managing the waste. The study will also look at options for funding the treatment of AMD and for managing the treatment plants.

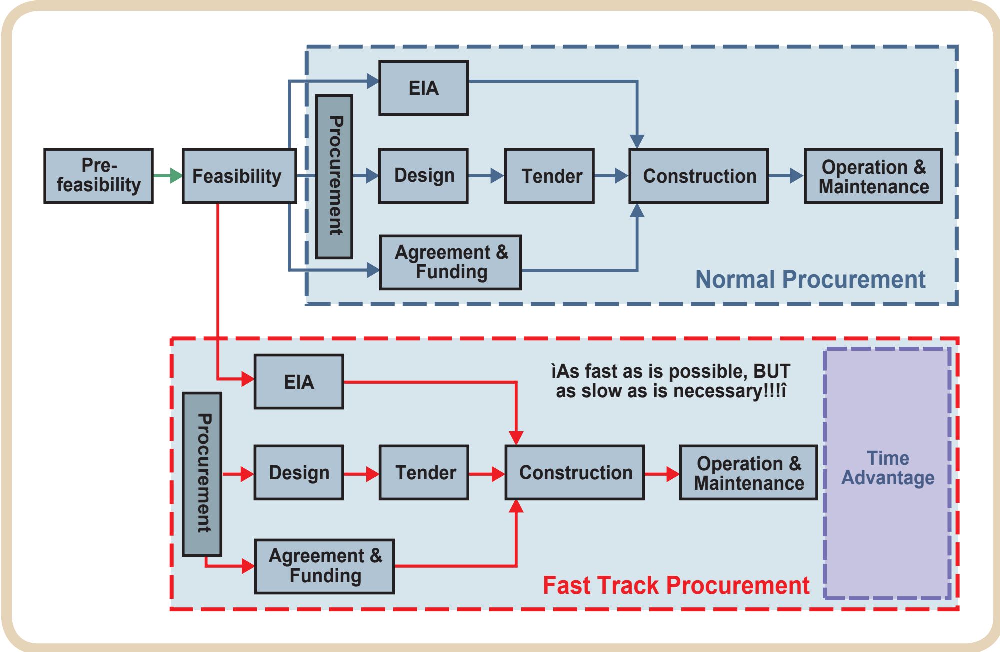
Although the preferred solution may be expensive it should consider the interest of the tax payer and also protect the interest of the water users in the Vaal River water supply area. Initial indications are that the Operating Expenditure (OPEX) associated for treating the AMD may be substantial, especially since such treatment will most likely be required for an indefinite period of time. Spending money and time now on a feasibility study can reduce the OPEX significantly and it is worthwhile to first consider all possible options for the long-term before making a final decision.



Feasibility study for the long-term solution – fast tracked

Fast tracking the process

Normally feasibility studies for most projects take 2-3 years to complete. Given the urgency to find a long-term solution to the AMD challenge this feasibility study is being fast tracked, both in terms of the study, which will be completed in 13 months and in terms of the implementation of the long-term solution.



Early information of the study indicates that commencement of implementation processes can be expedited if certain implementation related activities are initiated whilst the feasibility study is still in process. This will require a special effort from DWA to manage and coordinate the complex implementation actions in parallel to the study and to coordinate closely with other Government Departments and stakeholders.

In order for this to happen, exemption is required from National Treasury for issuance of the so called Treasury Approval 1 (TA 1), which is normally required before procurement can start. The exemption will save significant time as it will allow actions such as commencement of the Environmental Impact Assessment for the long-term solution, appointment of a Project Manager, and other actions to run in parallel with each other, and start before completion of the feasibility study.

The diagram shows only the main components of the project under a "traditional" implementation scenario. Note that there are many other actions that also need to take place, but that cannot be shown on this scale. In the top half of the diagram, the typical process that is expected to be followed for this project (from conception through to construction and operation and maintenance) is shown, if procurement with a normal programme is followed.

After the feasibility phase is completed and DWA has approved all the deliverables, the procurement of a Professional Service Provider (PSP) designer, and an EIA consultant can follow. While the EIA, design and tender is taking place, necessary or desirable agreements (access to land, water off-take agreements, etc.) and funding should be obtained. Once all of these are completed, construction can follow.

The lower half of the diagram illustrates the procurement processes commencing before the completion of the Feasibility Study, which can have a considerable time advantage, and that will benefit the assurance of supply situation associated with the Vaal System.

Risks of Fast Tracked Procurement

Any procurement process will have inherent risks, whether it be fast tracked procurement or according to a normal programme. However, some risks are likely to be higher for fast tracked procurement.

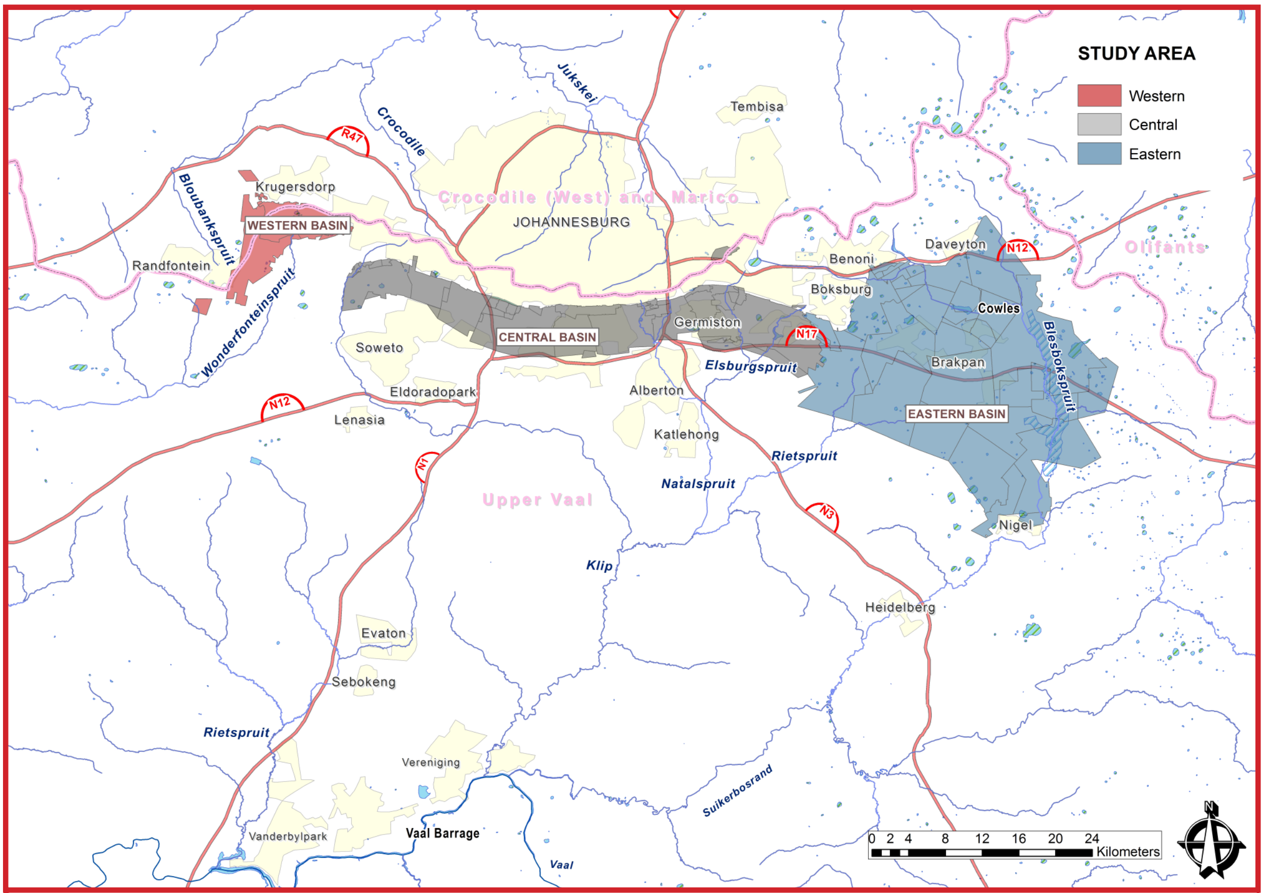
Fast track procurement places a time constraint on various implementation actions such as the statutory approvals and licensing, negotiations with landowners, stakeholder engagement (manage concerns and perceptions) and securing funding. The limited time might result in these actions not being finalised before the Request for Proposals need to be issued. Some key agreements, e.g., water use off-take agreements and waste purchase agreements might also not be finalised in time.

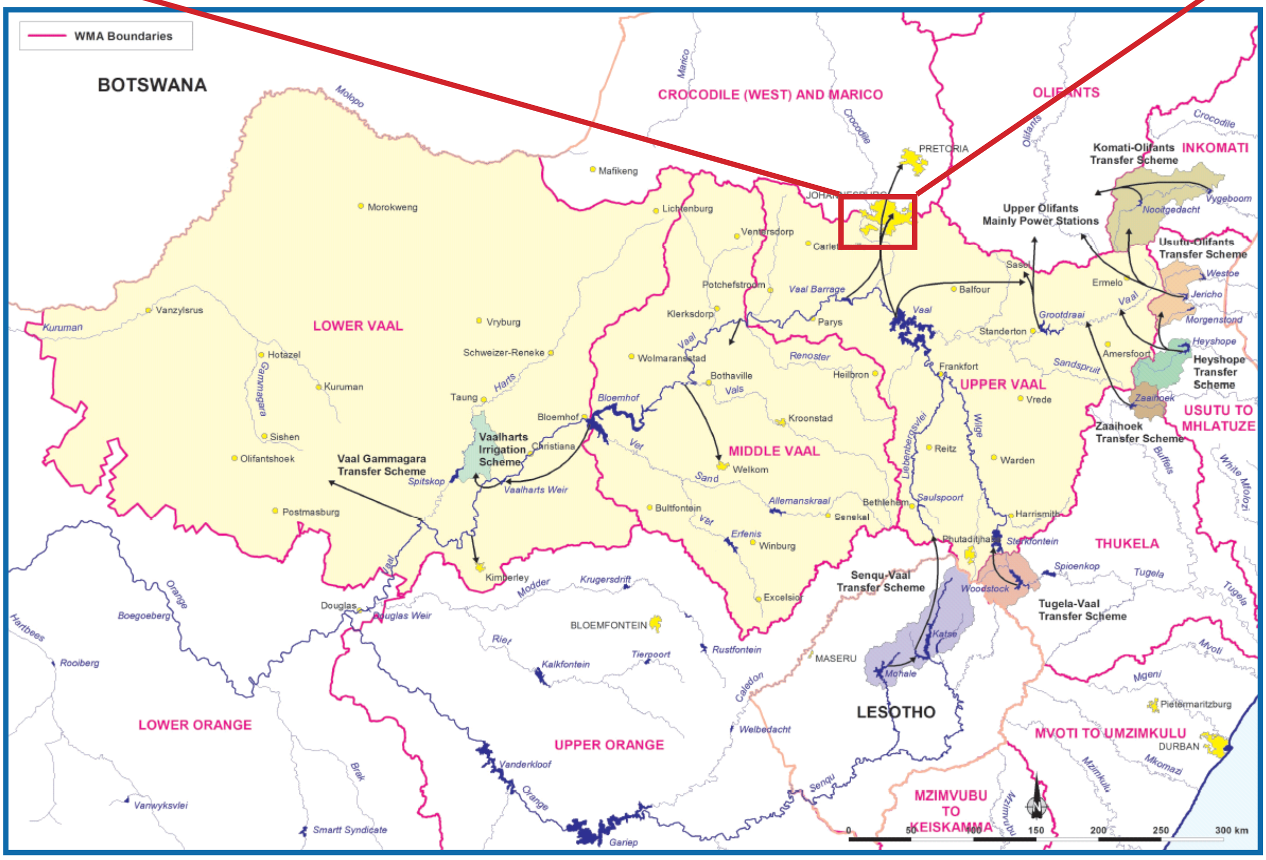
The Environmental Impact Assessment (EIA) and procurement documents will be based on preliminary information and may need adjustment as more information becomes available. Duplicate work might also be required in the EIA to cover alternative solutions.

Feasibility study for the long-term solution – study boundaries

The focus of the feasibility study is on the East, Central and West Rand underground mining basins, and will be considered in the context of the Vaal River water supply area and all associated affected catchments from an integrated water resource management perspective, as shown in the figure below.

The Western Basin covers the Krugersdorp, Witpoortjie and Randfontein areas. The Central Basin extends from Durban Roodepoort Deep (DRD) in the west to the East Rand Proprietary Mines (ERPM) in the east. The Eastern Basin covers the East Rand area, including the towns of Boksburg, Brakpan, Springs and Nigel.





Feasibility study for the long-term solution – scope

Study objectives

The objective of the study is to investigate and recommend a technically sound, economically viable and institutionally feasible long-term solution to the AMD situation in the study area.
This is to:

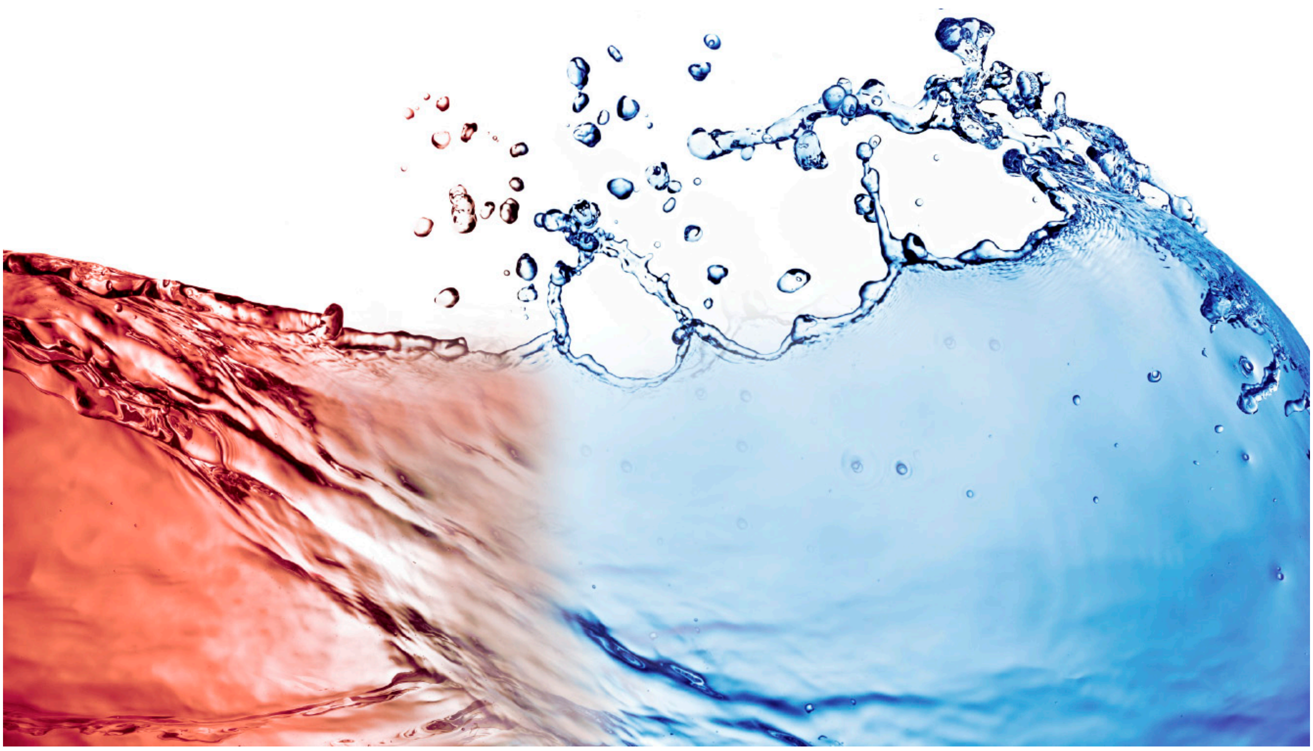
- Ensure long-term water supply security and continuous fitness for use of Vaal River water; and
- Endeavour to meet the requirement to remove mine water induced salt-loading by 2015 or soonest thereafter.

Study focus

Developing a long-term solution to address AMD requires the careful assessment and integration of the following focus areas:

- A sound understanding of the geohydrology, the underground water resource, sources of surface water ingress, spatial distribution and connectivity of mined voids, the current water quality and projections of future volumes, levels and water qualities;
- Identifying suitable technology options for potentially treating the AMD to standards that can be accepted by the environment or will be accepted by other users;
- Assessment of the options for the location, configuration and type of infrastructure required to potentially treat the AMD return-flows;
- Consideration of alternative options for a long-term solution that will prevent the salts from underground mine water from entering major river systems;
- Definition of the most desirable management scenario, technical option and end user(s), followed by an analysis of the infrastructure configuration and detailed value assessment of the selected option;
- The assessment of alternative institutional models for implementation, ranging from "traditional" government funded implementation to full private sector implementation, through Private Sector ownership or a Public Private Partnership (PPP), and any combinations thereof.

Recommending the most appropriate model for implementation, and in particular assessing the options for a PPP is not a common component of DWA studies and is probably the most challenging and certainly as important for a suitable solution, as the technical components. The most appropriate and sustainable model will be recommended.



Feasibility study for the long-term solution – Current Status

The project is currently well advanced with the pre-feasibility phase. Technical Options under consideration include:

- Potential raising of the ECLs (with monitoring) to levels that are still deemed "safe";
- Potential abstraction options (from old mine shafts, through multiple boreholes or through tunnels in the Western and Central Basins);
- Applications of passive treatment such as saline agriculture, considering the potential associated social benefit;
- Waste discharge options - (this is a very important challenge);
- Management and use of treated water; and
- Alternative treatment technologies.

The diagram below indicates the different categories of technology that are under consideration. Some technologies are already proven while others are still considered as innovative where it is still in pilot plant stage. There are also other technologies that are considered as embryonic and are not proven yet.

The Ideal Solution

The Institutional and Financial models that are to be considered should enable the effective management of the AMD challenge in a cost effective manner. The obligations of the state, civil society and business as well as the interests of the tax payer, and water user need to be considered. The optimum institutional and financial solution will need to be well balanced considering all the above factors. In the technical sphere, the optimal solution should not only be environmentally and financially sustainable but should also contribute to improving the water supply situation in the Vaal System. In this regard the solution to the AMD issue is a crucial element of the Vaal River Water Resource Management Strategies. The challenge of the study is to seek innovative solutions to convert an environmental threat into a water resource solution.

SUMMARY OF AMD TREATMENT TECHNOLOGIES

ACID NEUTRALIZATION	METALS REMOVAL	REMOVAL OF SALTS	REMOVAL OF SPECIFIC POLLUTANTS
Limestone ($CaCO_3$)	Precipitation as Hydroxides	Physical Desalination (Reverse Osmosis)	Radio- active nuclides Precipitation Ion Exchange
Lime ($Ca(OH)_2$)	Precipitation as Carbonates	Biological Sulphate Removal	Cyanide Removal Chemical Oxidation Biological Oxidation Complexation
Sodium based alkali ($NaOH$, Na_2CO_3)	Precipitation as Sulphides	Chemical Precipitation (ABC, SAVMIN)	
Biological Sulphate Reduction	Wetlands, Oxidation Ponds	Ion Exchange	Arsenic Removal Chemical Oxidation Reduction Biological Oxidation Adsorption
Ammonia		Passive Treatment Wetlands, Irrigation	
Wetlands, anoxic drains			Molybdenum Removal Iron Adsorption

Short-term Intervention Process shown in yellow

Feasibility study for the long-term solution- communication and way forward

Stakeholder Engagement and Communication

Since the feasibility study is a planning study to investigate different planning options and recommend a feasible long-term solution for the AMD challenges, it does not include a public participation process in terms of the National Environment Management Act (NEMA, Act 107 of 1998) (NEMA: 107:1998). However, once the feasibility study has progressed to the point where feasible options can be recommended and an institutional model has been agreed upon, an EIA practitioner can be procured and the EIA process may commence.
It is during this EIA process that all interested and affected parties will have an opportunity to register as stakeholders, participate and comment.

Who are key stakeholders?

Key stakeholders are defined as directly affected parties, those who have a high level of negative or positive influence (in government and civil society domains, and on the direction and success of AMD long-term initiatives) and those whose input is critical to the study (for e.g. representatives of various National, Provincial, and Local and District Government, NGOs, organised business, mining, industry, labour, agriculture, affected mines, affected water utilities, community leaders, academics etc

Objectives of key stakeholder engagement

The objectives of the engagement and communication component of the feasibility study are to:

- Undertake focussed engagement with identified key stakeholders and stakeholder sectors/ groups in various relevant fields at certain milestones throughout the study, to obtain their input and comments on concepts, principles and assessment of alternatives, etc.; and
- Communicate information on study progress and outcomes at certain milestones to the wider key stakeholder group, and provide opportunities for constructive input to inform the study.

	Information gathering to inform the study (existing information, monitoring data, technical input and expertise).	Communication with wider stakeholder group
PURPOSE	Information gathering to inform the study (existing information, monitoring data, technical input and expertise).	Communicate progress and key outcomes at certain milestones in the study.
METHOD OF ENGAGEMENT	• Individual consultation meetings; • Focus group meetings; • Technical workshops; • Study Stakeholder Committee (SSC) Meetings; and • Presentations by DWA to Catchment Forums and existing forums	• Newsletters at certain milestones in the study; • Press releases; • AMD webpage on the DWA website;

Study Stakeholder Committee (SSC)

The DWA has established a SSC comprising key representatives from both Government and the private sector to contribute inputs representing the broader stakeholder perspective. The SSC will be involved in the planning process where different options, perspectives, issues and implications are debated and considered.

Next Steps

The next steps in the feasibility study are now foreseen to be as follows:

- August 2012: Finalisation of pre-feasibility study recommendations.
- August 2012: Focus group meetings with key stakeholder sectors/ groups for their inputs to inform the study;
- August – mid October 2012: All technologies presented to the feasibility study team will be screened and considered.A Reference Process will be selected and priced;
- October 2012: Next SSC meeting to receive and provide information, and to discuss progress and draft outcomes of study components;
- November 2012: Newsletter and/or press release to update stakeholders on study progress, procurement options and recommendation;
- January/February 2013: Final SSC meeting to provide information and procurement options to discuss progress and draft outcomes of study components; and
- 28 February 2013: Study closure.