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**Water Resource Planning Systems  
Series**

**Water Quality Planning**

**Feasibility Study for a Long-  
Term Solution to address the  
Acid Mine Drainage  
associated with the East,  
Central and West Rand  
underground mining basins**

## **Feasibility Report**

**Study Report No. 10**

**P RSA 000/00/17012**

**July 2013**

**EDITION 1**

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**water affairs**

Department:  
Water Affairs  
**REPUBLIC OF SOUTH AFRICA**



DEPARTMENT OF WATER AFFAIRS

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Private Bag X313  
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Tel: (012) 336 7500/ +27 12 336 7500  
Fax: (012) 336 6731/ +27 12 336 6731

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### **Disclaimer:**

The study was very dynamic in nature and the available information is continuously being updated and expanded. It is confirmed that each report has been prepared for the purpose of the study using the information relevant and available at the time of compilation of the report. All necessary skill, care and diligence were exercised by the authors, contributors and reviewers during the compilation and approval of the reports. The reader needs to determine the relevance, reliability or usefulness of the information and data reported in this study, if it is used in whole or in part, for their own purpose. Reports should not be interpreted in isolation, but in the context of the study and all its deliverables as a whole.

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## DOCUMENT INDEX

### Reports as part of this study:

Study Report Number	DWA Report Number	Reports	SC	Conf.
1	P RSA 000/00/16112	Inception Report	1	
2	P RSA 000/00/16212	Status of Available Information	2	
3	P RSA 000/00/16312	Legal Considerations for Apportionment of Liabilities	3	#
4	P RSA 000/00/16412	Alternative Approaches for Apportioning Liabilities		#
5	P RSA 000/00/16512	Technical Prefeasibility Report	4	
5.1	P RSA 000/00/16512/1	Current Status of the Technical Management of Underground AMD		
5.2	P RSA 000/00/16512/2	Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids		
5.3	P RSA 000/00/16512/3	Options for Use or Discharge of Water		
5.4	P RSA 000/00/16512/4	Treatment Technology Options		
5.5	P RSA 000/00/16512/5	Options for the Sustainable Management and Use of Residue Products from the Treatment of AMD		
6	P RSA 000/00/16612	Concept Design	5	#
6.1	P RSA 000/00/16612/1	Concept Design: Drawings		#
6.2	P RSA 000/00/16612/2	Concept Design: Costing		#
7	P RSA 000/00/16712	Institutional, Procurement and Financing Options	6	#
8	P RSA 000/00/16812	Implementation Strategy and Action Plan	7	
9	P RSA 000/00/16912	Key Stakeholder Engagement and Communications	8	
9.1	P RSA 000/00/16912/1	Communication Strategy and Action Plan		
10	P RSA 000/00/17012	Feasibility Report		

SC: Study Component

Conf: Indication of Confidentiality

# - These reports will not be made available until the appropriate implementation process stages have been reached as they may potentially compromise future procurement and legal processes.

# **PREFACE**

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## **1. Background to the Study**

Gold mining in the East, Central and West Rand underground mining basins of the Witwatersrand goldfields (hereafter referred to as the Eastern, Central and Western Basins) started in the late 1880s. It is estimated that in the 1920s approximately 50% of the world's gold production came from the Witwatersrand mining belt, while in the 1980s South Africa was still the largest gold producer in the world. The large-scale mining in South Africa, in particular in the Witwatersrand, has decreased since the 1990s, and underground mining in the Witwatersrand essentially ceased in 2010. The mines of the Western, Central and Eastern Basins have produced a total of approximately 15 600 tons of refined gold since mining commenced. While the mines were operating, they pumped water to the surface to dewater their mine workings, but since mining stopped, the underground voids that were left after the mining have been steadily filling with water. The water in the mine voids interacts with the exposed sulphide bearing minerals in the rock formations to form Acid Mine Drainage (AMD), also known internationally as Acid Rock Drainage (ARD). AMD is characterised by a low pH and an excessive concentration of dissolved metals and sulphate salts.

In the case of the Western Basin, the AMD gradually reached the surface and started to drain out (decant) into surface streams in 2002. The water in the mine voids of the Central and Eastern Basins is rising steadily and will continue to do so until the water is pumped from the voids. It is predicted that the critical water levels will be reached in the Central Basin in late 2013 and in the Eastern Basin in mid-2014. If nothing is done, the water is predicted to reach the surface and decant at the lowest points in the Central Basin in the second half of 2015 and to reach the surface and decant in the Eastern Basin in late 2016. Decant would be uncontrolled and is likely to occur at several identified points, as well as at unexpected locations across each basin, due to varying water levels and connectivity between the near-surface aquifers and the voids.

If AMD, which has not been desalinated, is discharged into the Vaal River System, the high salt load will require large dilution releases to be made from the Vaal Dam to achieve the fitness-for-use objectives set for the Vaal Barrage and further downstream. This would result in unusable surpluses developing in the Lower Vaal River. Moreover, if dilution releases are still required after 2015, the acceptable levels of assurance of water supply from the Vaal Dam would be threatened. This will mean that there would be an increasing risk of water restrictions in the Vaal River water supply area, which will have negative economic and social implications. These negative impacts will be much greater if the catchment of the Vaal River System enters a period of lower-than-average rainfall with drought conditions. Since decant started in the Western Basin in 2002 the continuous flow of untreated AMD, and now the salt load from the continuous flow of the neutralised AMD from the Western Basin, impact on the Crocodile (West) River System.



The importance of finding a solution to the rising AMD and the need for inter-departmental cooperation led to the establishment of an Inter-Ministerial Committee (IMC) on AMD, comprising the Ministers of Mineral Resources, Water and Environmental Affairs, and Science and Technology, and the Minister in the Presidency: National Planning Commission. The first meeting of the IMC took place in September 2010.

The IMC established a Technical Committee, co-chaired by the Directors-General of Mineral Resources and Water Affairs, which instructed a Team of Experts to prepare a report advising the IMC on solutions to control and manage AMD in the Witwatersrand goldfields. In February 2011, Cabinet considered the IMC report and instructed that the recommendations be implemented as a matter of urgency. Funds were then allocated to the Department of Water Affairs (DWA) by National Treasury (NT) with the purpose of implementing some of the IMC recommendations, namely to:

- Investigate and implement measures to pump the underground mine water in order to prevent the violation of the Environmental Critical Levels (ECLs), i.e. specific underground levels in each mining basin above which mine water should not be allowed to rise so as to prevent adverse environmental, social and economic impacts;
- Investigate and implement measures to neutralise AMD (pH correction and removal of heavy metals from AMD); and
- Initiate a Feasibility Study to address the medium- to long-term solution.

The investigations and implementation actions proposed in the first two recommendations commenced in April 2011, when the Minister of Water and Environmental Affairs issued a Directive to the Trans-Caledon Tunnel Authority (TCTA) to undertake “Emergency Works Water Management on the Witwatersrand Gold Fields with Special Emphasis on AMD”.

When the proposed pumping and neutralisation commences in the Central and Eastern Basins the situation will be similar to that which prevailed when underground mining and dewatering of the mine voids, and partial treatment of the water, were being carried out by the active mining companies. The saline AMD will flow into the Vaal River System and specifically into the Vaal Barrage. The high salt load will have the same impact on the Vaal River System as described earlier.

The third recommendation resulted in the Terms of Reference (ToR) for this Feasibility Study (DWA 2011a) being issued in July 2011. The ToR noted that the IMC had recommended that a Feasibility Study should be initiated as soon as possible, since the Short-Term Interventions (STI) might influence the roll-out of the desired medium- to long-term solution.

In January 2012, DWA commissioned the Feasibility Study for the Long-Term Solution (LTS). The Study period was 18 months, with completion at the end of July 2013. It was emphasised that this Study was very urgent, would be in the public eye, and that recommendations to support informed decision-making by DWA were required. The recommended solution must support the Water Resource Strategies for the Vaal and



Crocodile West River Systems and take account of the costs, social and environmental implications and public reaction to the various possible solutions.

The urgency of reducing salt loading on the Vaal River System and the relatively short study period for such a complex study means that implementation decisions have to be based on the current understanding of the best available information and technical analyses that have been completed by the time the decisions must be made. Thus, a precautionary and conservative approach was adopted during the Study.

Opportunities have been identified where the solutions that are implemented can be refined, during operation, as more information becomes available.

## 2. Integration with the Short-Term Intervention

The final TCTA Due Diligence Report (TCTA, 2011) was submitted to DWA in August 2011, and tenders for construction in all the basins were invited in November 2011. Immediate works were implemented in the Western Basin in 2012, and construction in the Central Basin commenced in January 2013. It is anticipated that construction of the Eastern Basin will commence in the first quarter of 2014.

The Scope of Work (SoW) of this Feasibility Study, with respect to the STI, is to understand the proposed STI in sufficient detail to:

- Undertake a Feasibility Study of all options, irrespective of the STI, in the interests of finding the best LTS;
- Determine how to integrate the STI and LTS, and influence the STI as far as appropriate or practical;
- Identify any potential long-term risks associated with the proposed STI, and propose prevention or mitigation measures; and
- Assess the implications of the proposed STI for the suggested institutional model for the implementation, operation, maintenance and/or management of the preferred LTS.

## 3. Approach to the Study

The focus areas of the Feasibility Study comprise technical, legal, institutional, financial/economic and environmental assessments, as well as public communication and key stakeholder engagement. The Feasibility Study comprises three phases; the Initiation, Prefeasibility and Feasibility Phases. The main components and key deliverables of each phase are shown in **Figure 1**, and each phase is discussed in more detail below.

The technical assessments run in parallel with the legal assessment, and both feed into the options assessment. The component on stakeholder engagement and communication was started early in the Study so that a stakeholder engagement and public communication strategy could be developed as soon as possible and be implemented throughout the Study.

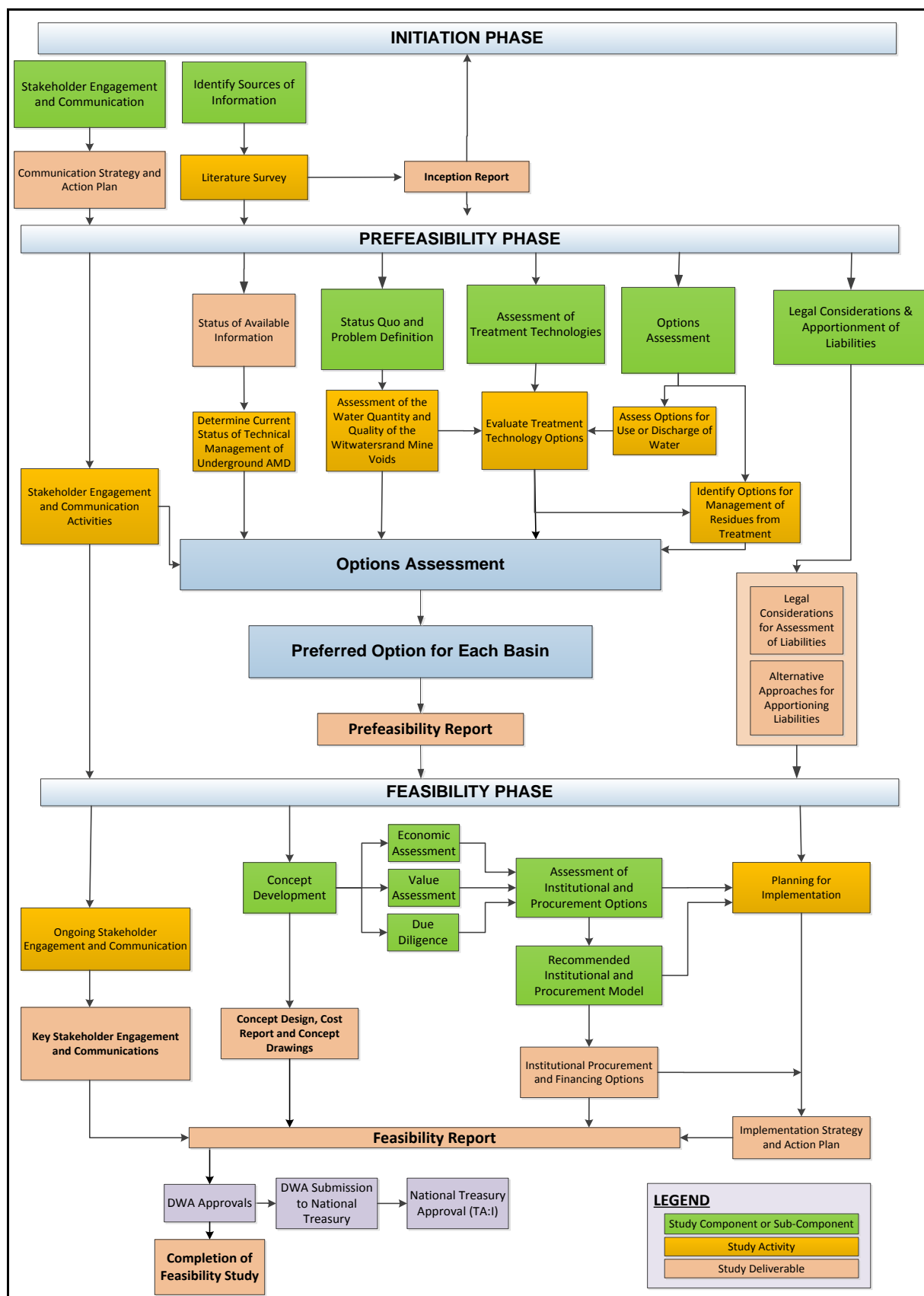
The planning showed the Feasibility Phase as following the Prefeasibility Phase, but the short study period meant that it was necessary for the Feasibility Phase components to commence during the Prefeasibility Phase and run in parallel.

In conducting the Study, it was important that each component developed key information and recommendations, which were then used in subsequent components. The logical and timeous flow of information and recommendations was essential in order to develop solutions and meet the Study programme.

**Figure 2** gives an overview of the technical, institutional/financial and implementation components and the flow of information throughout the Study. It can be seen how the fixed information (e.g. ECLs, raw water quality, ingress, etc.) and the decisions to be made, or the options to be investigated (e.g. abstraction points, qualities and quantities required by potential users, locations of users, treatment technologies) feed into the options assessment and identification of the Reference Project. The Reference Project will define the option that uses proven technologies, has the least associated risk, and is used for financial modelling and budgeting. It will probably not be the same as the option that is implemented, but constitutes the benchmark against which implementation proposals will be judged.

The Concept Design is based on the Reference Project and includes the costing and land requirements. This in turn provides input for the evaluation of the institutional procurement and financing options and the Implementation Strategy and Action Plan.

The phases of the Study, the key components and their inter-relationships are described below and illustrated in **Figures 1 and 2**.



**Figure 1: Study phases and components**

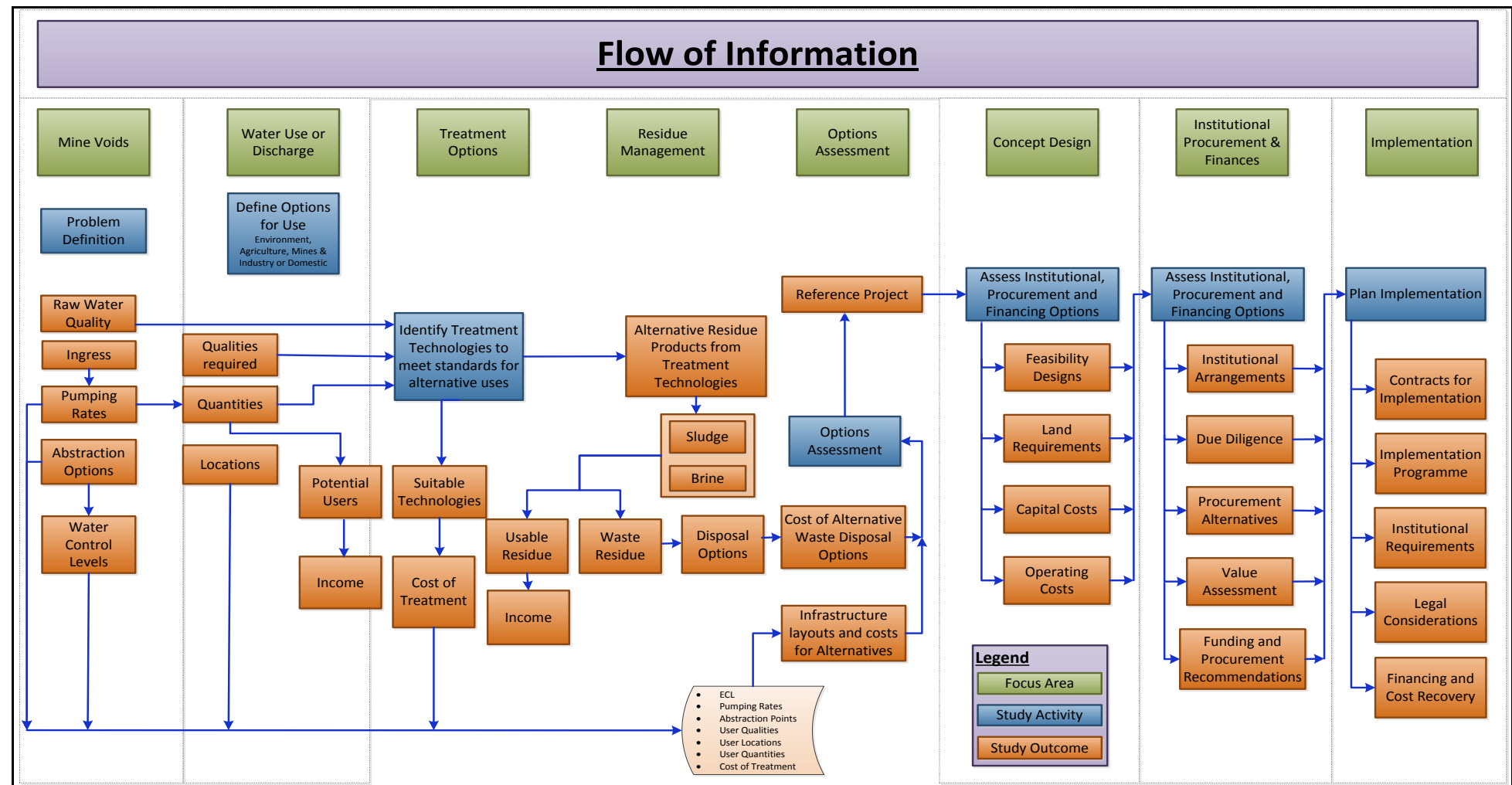


Figure 2: Flow of information throughout the Study

## PHASE 1: Initiation

The objective of the Initiation Phase was to determine on the approach and principles for the Study and understand the work already done by others. Numerous reports from previous studies, maps and research findings, relating to all components of the Study, were collated and reviewed. The SoW, proposed approach and the study programme were reviewed after initial consideration of the available information. The study objectives and priorities were reviewed and the results are presented in Study Report No. 1 ***“Inception Report”***.

The results of the complete literature survey, which continued after the Initiation Phase, are presented in Study Report No. 2 ***“Status of Available Information”***.

Study Report No. 9.1 ***“Communication Strategy and Action Plan”*** was prepared so that key stakeholder engagement and communications could commence as soon as possible and continue throughout the Study.

## PHASE 2: Prefeasibility

The purpose of this phase was to understand and describe the current status and the environment for managing AMD and then to identify all apparently viable alternative solutions and, from those, identify the more feasible options, on the basis of technical feasibility, social and environmental acceptability and cost effectiveness. These were then considered in more detail, and the most feasible options were investigated in the Feasibility Phase.

The assessment of the legal liabilities and mechanisms for the apportionment of liabilities is a key stand-alone component that was commenced in the Prefeasibility Phase and finalised in the Feasibility Phase. This work is described in Confidential Study Report No. 3 ***“Legal Considerations for Apportionment of Liabilities”*** and Confidential Study Report No. 4 ***“Alternative Approaches for Apportioning Liabilities”***.

The objectives of the Prefeasibility Phase were to:

- Understand the status quo;
- Define the problem;
- Understand the quantity and quality of water in the mine voids and how fast is it rising in each basin;
- Identify possible uses for the water;
- Identify treatment technologies that can treat the necessary volumes of AMD to the standard required by various users;
- Understand the residues (or waste products) produced by each process and how they can be managed;
- Define a wide range of options for possible solutions by combining alternatives for abstraction, water use, treatment and management of residues;
- Screen the alternatives to identify viable options; and

- Carry out prefeasibility costing of the most viable options and identify the most appropriate option to be used as the Reference Project.

To achieve these objectives, the Prefeasibility Phase needed to provide the team with:

- i. A sound understanding of the STI, how it can be integrated into the LTS, and the impact of the STI on the selection and procurement of the LTS. This is described in DWA AMD FS 2013, Study Report No. 5.1 ***“Current Status of Technical Management of Underground AMD”***.
- ii. A sound understanding of the hydrogeology, underground water resources, sources of surface water ingress, spatial distribution and connectivity of mined voids; and the current water quality and projections of future volumes, levels and water qualities. This was based on the substantial information from previous studies and is presented in DWA AMD FS 2013, Study Report No. 5.2 ***“Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids”***.
- iii. An understanding of the DWA Water Resource Management Strategies for the Vaal River System and Crocodile West River System. These strategies provided the framework within which to develop a range of possibilities for the use or discharge of raw, neutralised or desalinated AMD to meet the objective of reducing the salt load in the Vaal River System and associated catchments to acceptable levels without having an unacceptable social or environmental impact. These possibilities are described in DWA AMD FS 2013, Study Report No. 5.3 ***“Options for Use or Discharge of Water”***.
- iv. An assessment of suitable technologies for treating either raw AMD or the discharges from the STI to standards that will not negatively impact on the environment and will be acceptable to a range of users. This assessment is described in DWA AMD FS 2013, Study Report No. 5.4 ***“Treatment Technology Options”***.
- v. Locality plans for the possible disposal of waste, or potential uses for residue products generated by treatment processes. These plans are described in DWA AMD FS 2013, Study Report No. 5.5 ***“Options for the Sustainable Management and Use of Residue Products from the Treatment of AMD”***.

The knowledge and data from the Prefeasibility Phase were used to combine the alternative locations for the abstraction, treatment and use or discharge of water and the disposal of waste, as well as the layouts of the infrastructure required (including pipelines and pump stations), into a large number of options. The alternatives were screened at a high level to give a short-list of practical technical options.

The capital and operating costs of the short-listed options were determined to give a present value of lifetime cost. Social and environmental screening for fatal flaws was carried out, and possible financial benefits from the sale of water or waste were considered. The anticipated public reaction to the options was also considered. The identification of the Reference Project was then completed on the basis of the costs, benefits and impacts. The costs and

implications of possible alternatives were also defined. The results and an overview of all the components of this Prefeasibility Phase are described in DWA AMD FS 2013, Study Report No. 5 **“Technical Prefeasibility Report”**.

### PHASE 3: Feasibility

The main objective of this phase was to carry out intensive feasibility level investigations and optimisation of the most feasible layouts for each basin and to select a preferred option to be used as a Reference Project for each basin. The requirements for implementation were also considered and evaluated.

The Feasibility Phase comprises a number of components that build on the results of the Prefeasibility Phase; the results of the various components are reported separately and then integrated in a Feasibility Report for the solution to AMD.

The components in this Phase comprise:

i. Concept Development:

Once the Reference Project for each basin had been agreed, the layout for the treatment works, pipelines and waste storage and disposal sites was planned and costed. Environmental screening was undertaken for each of the identified sites that form part of the Reference Project. The results are presented in DWA AMD FS 2013, Confidential Study Report No. 6 **“Concept Design”**, DWA AMD FS 2013, Confidential Study Report No. 6.1 **“Concept Design Drawings”** and DWA AMD FS 2013, Confidential Study Report No. 6.2 **“Concept Design Costing”**.

ii. Institutional Procurement and Financing Options:

The following alternative procurement models for implementation were evaluated:

- a ‘traditional’ Government-funded and a traditionally procured Employer Design, Procure, Construct and Operate solution, which is the Public Sector Comparator model (PSC);
- a Design, Build, Operate and Maintain (DBOM) scenario funded by an Implementing Agent, using Private Sector or Government funding, which is also a Public Sector Comparator model (PSC); and
- a private sector-funded Public Private Partnership (PPP).

The approach included a detailed risk-adjusted value assessment of the PSC and DBOMF (PPP) models for the Reference Project in each of the three basins. The possible institutional arrangements were assessed in terms of the roles and responsibilities of the responsible organisations.

A due diligence assessment was carried out to establish the legal mandates of the institutions, as well as ownership of the land required for the Reference Project. These assessments are described in DWA AMD FS 2013, Confidential Study Report No. 7 **“Institutional, Procurement and Financing Options”**.



iii. Implementation Strategy and Action Plan:

Throughout the Study, the requirements for implementation were considered in developing an Implementation Plan. Where necessary, the activities required for implementation that must commence in parallel with this Study were identified. This included the preparation of a Request for Information (RfI), which initiated a process through which service providers could register their interest with DWA. All the requirements for implementation are described in DWA AMD FS 2013, Study Report No. 8 ***“Implementation Strategy and Action Plan”***.

iv. Key Stakeholder Engagement and Public Communication:

Engagement with key stakeholders and public communication were very important components of the Study and were on-going from the commencement of the Study to the completion of the work. Study Stakeholder Committee meetings, Focus Group meetings, a RfI, one-on-one meetings, newsletters and a website were key elements. The process and results are presented in DWA AMD FS 2013, Study Report No. 9 ***“Key Stakeholder Engagement and Communications”***.

The final deliverable, DWA AMD FS 2013, Study Report No. 10 ***“Feasibility Report”***, summarises the results of the Study.

The Prefeasibility Phase and Concept Development in the Feasibility Phase are typical components of many planning studies. Solving the technical issues is not normally the biggest challenge, although this project does have several unique aspects. However, the Feasibility Phase components that lead to recommendations for appropriate institutional, financial and procurement models for implementation, particularly the assessment of the options for procurement, are not common components of DWA studies and were the most challenging, and certainly as important for a sustainable solution as all the technical components combined.

## 4. Way Forward

Completion of the Study will provide all the information required for implementation to proceed, although DWA plans to start the preparations required for implementation in parallel with Phase 3 of this Study.

Following from the Feasibility Study, implementation should be carried out as soon as possible. The key activities required for implementation include the following:

- DWA submitting the Feasibility Study Reports to NT for their review and approval. The project has been registered with NT, and Treasury Approval 1 (TA 1) may be required before procurement can commence;
- Conducting an Environmental Impact Assessment (EIA); and
- The preparation of procurement documents.

If procurement is for a Design, Build, Operate and Maintain (DBOM) contract, the procurement documents will comprise:

- A Request for Qualifications (RfQ) to allow DWA to short-list suitably qualified service providers;

This will allow any service provider, especially those with proprietary technologies that may well be more cost effective than that used as the reference technology, to submit detailed information. Those that best meet the selection criteria, which will have to be agreed, will be short-listed; and

- A Request for Proposals (RfP) to be issued to the short-listed service providers, inviting them to submit tenders to implement a project that will deliver water to the specified standards.

If procurement is to follow the traditional process (with three sequential tenders for a service provider to prepare design and tender documentation, followed by tenders for construction, and then tenders for operation and maintenance), then the two-phase RfQ and RfP route may also be followed, with appropriate requirements specified at each stage.

The Reference Project could be implemented, but may not be the most effective solution. It will provide the yardstick methodology and costing which will be used to evaluate the tenders which are submitted.

DWA will also need to source the technical and contractual expertise required to enable them to manage the implementation of the desired long-term solution in each of the three basins.

*NOTE: A List of Acronyms and Glossary of Terms appear on pages lvi and lx respectively.*



## APPROVAL

**TITLE:** Feasibility Report  
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**AUTHORS:** Study Team  
**INTERNAL REVIEWER:** Andrew Tanner  
**LANGUAGE REVIEWER:** Robyn Arnold  
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Approved by the Study Component's Advisors:

  
Mr John Samuel

Institutional and Financial Advisor

  
Mr André Hindley

Legal Advisor

Approved for Aurecon South Africa (Pty) Ltd:

  
Mr Andrew Tanner

Lead Technical Advisor

  
Mr Fanie Vogel

Study Leader

Approved for the Department of Water Affairs:

  
Mr Jurg van Wyk

Scientist Manager: Water Quality Planning: Central

  
Mr Pieter Viljoen

Scientist Manager: Water Quality Planning

  
Dr Beason Mwaka

Director: Water Resources Planning Systems



# ACKNOWLEDGEMENTS

The following individuals and organisations are thanked for their contributions to the study:

## Study Administration Committee (SAC)

Jurgo van Wyk	Department of Water Affairs (DWA): Water Resource Planning Systems (WRPS)	Chairman / Study Manager
Jacqueline Jay	DWA: WRPS	Member / Study coordinator
Peter Pyke	DWA: Options Analysis	Member
Seef Rademeyer	DWA: National Water Resource Planning	Member
Rod Schwab	DWA: WRPS	Member
Pieter Viljoen	DWA: WRPS	Study Deputy Director
Fanie Vogel	Aurecon SA (Pty) Ltd	Study Leader
Andrew Tanner	Aurecon SA (Pty) Ltd	Technical Advisor
Joanne Henrico	Aurecon SA (Pty) Ltd	Project Administrator
André Hindley	SRK Consulting SA (Pty) Ltd	Legal Advisor
John Samuel	Turner & Townsend (Pty) Ltd	Institutional and Financial Advisor

## Study Management Committee (SMC)

### Chairman and Co-Chairman:

Beason Mwaka	DWA: Water Resource Planning Systems	Study Director
Pieter Viljoen	DWA: Water Resource Planning Systems	Study Deputy Director

### SAC plus the following members / alternative members:

Yacob Beletse	Agricultural Research Council (ARC)- Roodeplaat
Henk Coetzee	Council for Geoscience (CGS)
Fortress Netili	Council for Geoscience
Humberto Saeze	Council for Geoscience
Peter Kelly	Department of Mineral Resources (DMR)
Mahlori Mashimbye	Department of Science and Technology (DST)
Umeesha Naidoo	Department of Science and Technology
Shanna Nienaber	Department of Science and Technology
Henry J. Roman	Department of Science and Technology
Candice Willard	Department of Science and Technology
Nigel Adams	DWA: Compliance Monitoring and Enforcement
Kurt Fortuin	DWA: Capital Projects
Ernst Bertram	DWA: Hydrological Services
Nico de Meillon	DWA: Hydrological Services
Fanus Fourie	DWA: Water Resource Planning Systems
Bashan Govender	DWA: Gauteng Regional Office
Marius Keet	DWA: Gauteng Regional Office
Alice Mabasa	DWA: Hydrological Services
Dumisani Maluleke	DWA: Resource Protection and Waste
Zacharia Maswuma	DWA: Hydrological Services
Paul Meulenbeld	DWA: Water Abstraction and Instream Use
Nancy Motebe	DWA: Reserve Requirements
Thivhafuni Nemataheni	DWA: Resource Protection and Waste
Linda Page	DWA: Communication Services
Sputnik Ratau	DWA: Communication Services
Anil Singh	DWA: Legal Services
Eddie van Wyk	DWA: Hydrological Services
Maswuma Zacharia	DWA: Hydrological Services
Strover Maganedisa	National Treasury
Tawanda Nyandoro	Rand Water
Johann Claassens	Trans-Caledon Tunnel Authority (TCTA)
Craig Hasenjager	Trans-Caledon Tunnel Authority

**Study Stakeholder Committee (SSC)****Chairman:**

Solly Mabuda

DWA: Integrated Water Resource Planning

Chief Director

**SMC plus the following members/ alternative members:**

Meiring du Plessis	Agri Gauteng/ Private Consultant
Stephina Mudau	Chamber of Mines
Freddie Letsoko	City of Johannesburg Metropolitan Municipality (CoJ)
Pule Makena	City of Johannesburg Metropolitan Municipality
Antonino Manus	City of Johannesburg Metropolitan Municipality
Daniel Masemola	City of Johannesburg Metropolitan Municipality
Mukondi Masithi	City of Johannesburg Metropolitan Municipality
Dumisani Tinghisi	City of Johannesburg Metropolitan Municipality
Keith Bristow	Commonwealth Scientific Industrial Research Organisation
Bettina Genthe	Council for Scientific and Industrial Research (CSIR)
Phil Hobbs	Council for Scientific and Industrial Research
Amanda Britz	Department of Environmental Affairs (DEA)
Pumeza Skepe-Mngcita	Department of Environmental Affairs
Mpho Lithakanyane	Department of Mineral Resources (DMR)
Max Madubane	Department of Mineral Resources
Mashudu Maduka	Department of Mineral Resources
Susan Malebe	Department of Mineral Resources
Ethel Sinthumule	Department of Mineral Resources
Trevor Balzer	DWA: Chief Operations Officer
Herman Keuris	DWA: Information Programmes
Mbangiseni Nephumbada	DWA: Water Resources Information Management
Pieter de Vries	Ekurhuleni Metropolitan Municipality
Sekhonyana Lerothi	Ekurhuleni Metropolitan Municipality
Elsabeth van der Merwe	Ekurhuleni Metropolitan Municipality
Mariette Liefierink	Federation for a Sustainable Environment (FSE)
Koos Pretorius	Federation for a Sustainable Environment
Vukosi Ndlopfu	Gauteng Department of Agriculture and Rural Development (GDARD)
Rina Taviv	Gauteng Department of Agriculture and Rural Development
Elias Sithole	Gauteng Department of Local Government and Housing
Ariel Mafejane	Johannesburg Water
Jones Mnisi	Johannesburg Water
Ntshavheni Mukwevho	Johannesburg Water
Stephan du Toit	Mogale City Local Municipality
Emily Mathe	Mogale City Local Municipality
Andy Mathibe	Mogale City Local Municipality
Jacques Hugo	National Economic Development and Labour Council (NEDLAC)
Sharna Johardien	National Economic Development and Labour Council
Tumi Monageng	National Economic Development and Labour Council
Mahandra Naidoo	National Economic Development and Labour Council
Petrus Matji	National Treasury
Tumisang Moleke	National Treasury
Nokwazi Ndlala	Randfontein Local Municipality
Madiba Ramatlhape	Randfontein Local Municipality
Reveck Hariram	Rand Water
Vusimuzi Khubeka	Rand Water
Percy Khumalo	Rand Water
Solomon Mathebula	Rand Water
Sipho Mosai	Rand Water
Trevor Stubbs	Save the Vaal
Angela Kariuki	South African Human Rights Commission (SAHRC)
Janet Love	South African Human Rights Commission
Delysia Weah	South African Human Rights Commission
William Moraka	South African Local Government Association (SALGA)



Jacky Samson	South African Local Government Association
Lulama Xongwana	South African Local Government Association
Immanda Louw	South African Nuclear Energy Corporation
Solwazi Majola	Technology Innovation Agency (TIA)
Lynette du Plessis	Transvaal Agricultural Union SA
Bennie van Zyl	Transvaal Agricultural Union SA
Richard Holden	Trans-Caledon Tunnel Authority (TCTA)
Sophia Tiale	Trans-Caledon Tunnel Authority
John Annandale	University of Pretoria
Wayne Truter	University of Pretoria
Michael van der Laan	University of Pretoria / Agri Gauteng
Zain Mohamed	Vaal Barrage Reservoir, Leeuspruit and Taaibosspuit Forum/ Sasol
Phineas Malapela	Vaal Environmental Justice Forum
Jo Burgess	Water Research Commission (WRC)
Zakhele Dlamini	West Rand District Municipality
Danny Govender	West Rand District Municipality
Herina Hamer	West Rand District Municipality
Susan Stoffberg	West Rand District Municipality
Musa Zwane	West Rand District Municipality
Johnny de Araujo	Witkoppie Farm
Mike Muller	Wits University School of Public and Development Management/ National Planning Commission
Manuel Marino	World Bank
David Sislen	World Bank
Marcus Wishart	World Bank

In addition to the contributions received from the study committees mentioned above, inputs were also received from the following broad groups and sectors through focused discussions (a more comprehensive list is available on the DWA AMD website):

Academic institutions;  
Funding organisations;  
Global perspectives on AMD management;  
Environmental and conservation groups;  
Independent individuals in their private capacity;  
Institutions, parastatals and research facilities;  
Local, provincial and national government;  
Mining sector;  
Non-governmental organisations;  
Organised agriculture;  
Organised business, industry and labour;  
Other specialist fields/consultants;  
Tourism and recreation;  
Utilities/water service providers; and  
Various technology providers who offered information.

Organisations that provided considerable data and inputs for assessment and consideration, including the but not limited to, FSE, the Centre for Environmental Rights, Sasol, DST, WRC, Ekurhuleni Municipality, Rand Water, GDARD, DEA, CGS, DMR as well as various individuals in their private capacity, are thanked for their contributions.

WISA Mine Water Division, a division of the Water Institute of Southern Africa, agreed to peer review selected key reports from the Feasibility Study for the Department of Water Affairs. The Division offered to identify and carry the cost of the appointment of the independent external experts. The assistance of WISA Mine Water Division and the inputs from their experts are duly appreciated and acknowledged. The comments and suggestions by the following experts contributed significantly to the quality of the study: Achim Wurster (Private Consultant), Ingrid Dennis (North-West University), André van Niekerk (Golder and Associates) and Phil Hobbs (CSIR).

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The firms comprising the Professional Services Provider team for this study were:

Aurecon South Africa (Pty) Ltd;  
SRK Consulting (South Africa) (Pty) Ltd;  
Turner & Townsend (Pty) Ltd;  
Shango Solutions;  
Ledwaba Mazwai Attorneys;  
IGNIS Project & Finance Solutions (Pty) Ltd;  
Kayamandi Development Services (Pty) Ltd;  
Thompson & Thompson Consulting Engineers and Legal Services;  
Shepstone & Wylie Attorneys; and  
Various independent consultants, not mentioned separately.

# Executive Summary

## INTRODUCTION

*The Preface provides the background to the challenge of Acid Mine Drainage (AMD) in the Witwatersrand and describes the scope of the Study, as well as the approach followed to recommend the Long-Term Solution (LTS) for managing the AMD associated with the West, Central and East Rand underground mining basins (Western, Central and Eastern Basins). It also summarises the current Short-Term Interventions (STI) to control AMD, which are discussed in more detail in the report.*

*This DWA AMD FS 2013, Study Report No. 10 “**Feasibility Report**” summarises the main findings of all the reports for this Study, and concludes by making some recommendations for inclusion in a National Strategy for managing AMD.*

*The AMD situation in July 2013 was as follows.*

- In the Western Basin, the first phase of the Immediate Works had been implemented, and decant was stopped in mid-2012. Only neutralised water was being discharged into the Tweelopies Spruit, resulting in some improvements in the condition.*
- In the Central Basin, the STI is installing pumps in the ERBM SWV Shaft and a High Density Sludge (HDS) neutralisation plant is under construction. Commissioning is due in early 2014. Neutralised water will be discharged into the Klipspruit.*
- In the Eastern Basin, the tender for the STI works, pumps for abstraction, an HDS plant and ancillary works at Grootvlei No. 3 Shaft has been advertised, and commissioning of the works is scheduled for December 2014. The neutralised water from the HDS plant will be discharged into the Blesbokspruit.*

*The discharge of neutralised but saline water into the Crocodile (West) and Vaal River Systems is not sustainable, and the LTS should be implemented as soon as possible. The LTS comprises the implementation of treatment plants and ancillary works to desalinate the neutralised water, supply the water to suitable users and manage the residues from the treatment. In parallel, a number of other important activities to complete the recommendations of this Study for the long-term management of AMD in the Witwatersrand should be executed.*

*The purpose of the LTS is to ensure continued fitness for use of water in the Vaal and Crocodile (West) River Systems through managing the AMD from the three Witwatersrand mining basins. The options for the use or disposal of water derived from the management of AMD must be evaluated against the backdrop of the river system reconciliation strategies for the Vaal, Olifants and Crocodile (West) River Systems.*

## NEEDS ASSESSMENT

*In the Western and Eastern Basins, the LTS could influence the planning of the STI. In the Central Basin, the location of the abstraction and neutralisation plants for the STI contract was already fixed and any changes would have delayed implementation, probably leading to breaching of the Environmental Critical Level (ECL) and unacceptable environmental risks.*

*This Study reached somewhat different conclusions on the critical water levels, predicted water quality and required pumping rates from the understandably conservative findings of the STI study. If this Study's conclusions are correct, the adjustments that will inevitably be required during operation of the STI can easily accommodate these recommendations.*

*However, the STI proposals are considered acceptable to meet the requirements as stipulated in the directives that were issued by the Department of Water Affairs to the Trans-Caledon Tunnel Authority (TCTA).*

### Critical water levels

*A key objective was to define critical water levels in each of the basins and estimate the time at which the water in each basin will reach these levels. The critical water levels under consideration are:*

- The Environmental Critical Level ECL, being the level above which the water in the mine voids should not be allowed to rise in order to protect certain environmental features, including groundwater resources.*
- The Socio-Economic Critical Level (SECL), being the level above which the water in the mine void must not be allowed to rise in order to protect certain social or economic features; and*
- The Target Operating Level (TOL), being the level in the mine void at each abstraction point at which the water surface should generally be maintained in order to allow sufficient buffer capacity for the hydraulic gradient across the basin, seasonal peak ingress and pump down time.*
- Determining the highest ECL or SECL to minimise pumping costs and protect shallow aquifers and infrastructure lead to the recommended levels which are given in Table 1 at the end of this Executive Summary.*

### Surface Water Ingress

*The impact of surface water ingress directly into the underground workings is significant for all three basins. The plans of the Department of Mineral Resources (DMR), through the Council for Geoscience (CGS) to implement river canalisation as a control measure in the Central Basin should be implemented as soon as possible. Further studies on controlling ingress in the Western and Eastern Basins, are also urgently required to realise potential cost reduction.*

## **Water Quality**

*The data sources utilised in this study report lower salt concentrations than those recorded by the TCTA, partly due to the dilution effects from surface water ingress.*

## **Selection of Locations for Abstraction**

*The success of the abstraction method chosen depends on its ability to lower the void water level to ensure that decant and pollution of groundwater does not occur, and abstract the best quality water possible. It is considered preferable to abstract from shafts or inclines that are well connected with the mine void at shallow levels to maximise the recycling of shallow ingress, leaving the deep, highly contaminated water undisturbed.*

*For the Western Basin, Rand Uranium No. 8 Shaft met all the criteria and is currently used to pump AMD water. However, its stability is a concern and the STI is considering using No. 9 Shaft.*

*For the Central Basin, tenders had already been invited for pump installation and on HDS treatment plant at the South West Vertical (SWV) Shaft at ERPM when this Study began. A disadvantage of this shaft is that the shallowest connection to the mine void is relatively deep, but it is expected that the water which decants below surface from other compartments to the SWV compartment will be predominantly shallow water. This Study considers the SWV Shaft to be suitable for at least the medium term (10 to 15 years), but recommends further investigations for the long-term.*

*In the Eastern Basin, Grootvlei No. 3 Shaft is considered marginally superior to Marievale No. 5 Shaft, as it draws directly from the shallower Kimberley Reef void and only indirectly from the deeper Nigel Reef void and successful pumping was carried out at Grootvlei No. 3 Shaft in the past. The STI has invited tenders for abstraction and treatment works at Grootvlei No. 3 Shaft. Marievale No. 5 Shaft could be a suitable alternative should the need arise. Pumping from more than one shaft may be desirable.*

## **Design Capacity of Pumps and Treatment Works**

*The following recommendations are made for the abstraction works and treatment works:*

- The treatment works should be planned to be able to treat incoming water quality at the 95<sup>th</sup> percentile, but are expected to receive water of a quality between the 50<sup>th</sup> and 75<sup>th</sup> percentiles for much of the time;*
- The infrastructure should be designed to handle the expected average flows in 19 hours or the peak flows in 24 hours, whichever is the greater; and*
- Cost-effective measures to reduce ingress should be identified and implemented as a matter of urgency, since considerable savings are possible.*

## **OPTIONS FOR A LONG-TERM SOLUTION**

Various combinations of the alternative abstraction points, treatment processes, waste disposal options, and alternative end-users for the treated water from each basin were considered into the Prefeasibility Phase. Alternative combinations of options were evaluated and a single combination of options was recommended as a Preliminary Reference Project for each basin for further evaluation during the Feasibility Phase.

The following options were combined into complete solutions for Prefeasibility assessment.

- (i) Water Discharge to the environment.
- (ii) Water Supply to Rand Water for local potable or industrial use, or for remote industrial users.
- (iii) The technologies considered in the options analysis were:
  - HDS for neutralisation;
  - Conventional RO for desalination; and
  - A biological process (although not proven) if located near a wastewater treatment works (WWTW).
- (iv) The Residue management options were:
  - HDS and RO sludge to Sludge Storage Facility (SSF); and
  - Co-disposal of brine to the SSF. Since this was common to all options it did not influence the evaluation.

## **PREFEASIBILITY SELECTION OF OPTIONS FOR FEASIBILITY LEVEL ASSESSMENT**

The objective of the Prefeasibility selection was to consider all possible solutions and from those select the most promising for further study in the Concept Development component of the Study. The Prefeasibility selection process resulted in a limited number of preliminary Reference Projects for each basin. The Concept Development then assessed these in more detail and defined a Reference Project for each basin which is a low risk solution against which alternatives can be assessed. A total of 47 options were screened for feasibility, and 12 options were selected for further consideration.

Following this options assessment, the preliminary Reference Projects were selected in each basin based on satisfying the key drivers, namely:

- Using abstraction points with good connectivity to the entire basin at as shallow a level as practical to ensure that the ECL/SECL is protected with the highest practical TOL;
- Acceptable users/uses for the treated water which will result in the removal of salts from the Vaal and Crocodile (West) River Systems;
- Utilising the Reference Treatment processes to meet the requirements of users;
- Utilising as much infrastructure as appropriate from the STI; and

- *Providing the most economical solution that is socially and environmentally acceptable.*

*The recommended preliminary Reference Project for each basin that were considered in the Concept Design are described below:*

### **The Western Basin**

*It is recommended that, after neutralisation a conventional reverse osmosis (RO) plant at RU Shaft No. 8 or No. 9 be adopted as the Reference Project, with the end-user of the treated water being determined through negotiation between the Department and Rand Water.*

### **Central Basin**

*The preliminary Reference Project is abstraction from SWV Shaft, neutralisation by High Density Sludge (HDS), desalination by conventional RO, and delivery to Rand Water for supply to local industries. However, the location of water users should take into account the use of water from the Eastern Basin.*

### **Eastern Basin**

*The selected preliminary Reference Project is neutralisation by HDS and desalination by conventional RO at Grootvlei No. 3 Shaft, with delivery to Rand Water for supply to the end-user for industrial use. The final solution might consider including Central Basin water in the delivery system of the Eastern Basin.*

## **CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE**

*The Reference Projects which were developed from the Prefeasibility Phase were used for the technical due diligence, economic assessment and value assessment, funding and cost-recovery proposals.*

*A technical due diligence assessment was performed on the Reference Project for each basin. The Reference Project for each basin is summarised in **Table 1**.*

### **Western Basin**

*There are no anticipated connectivity issues in using the Rand Uranium No. 8 Shaft, but the stability of the shaft should be checked. The ground comprises shale, quartzite and lava; the excavations are likely to be soft to intermediate but suitable for construction. The land is not listed as environmentally sensitive in terms of Gauteng Department of Agricultural and Rural Development (GDARD's) Conservation Plan (CPlan) and it is not actively used for agriculture. The traffic impact of the LTS project in the area will be negligible. A new access road to the site for the plant will be designed and constructed under the STI. There are no visible heritage buildings.*

### **Central Basin**

*The South West Vertical (SWV) Shaft chosen for the STI provides challenges due to the connectivity with the mining void being at a very deep level. Geotechnical investigations*



*indicate that the site is suitable for the required construction works. The land is not listed as environmentally sensitive in terms of GDARD's CPlan. The area around the treatment site is an industrial area and additional traffic due to the LTS will be negligible. There are no visible heritage buildings.*

### **Eastern Basin**

*Grootvlei No. 3 Shaft, which has been chosen as the pumping shaft for STI, is well connected to the entire basin. The site is suitable for the intended construction works, but a geophysical and geo-hydrological investigation is required to determine the stability of founding grounds to carry water-bearing structures. The risk of raw AMD entering the wetland within which the site is situated constitutes a fatal flaw. Marievale Shaft No. 5 should thus be considered as an alternative. Another environmental risk is the pollution of the Blesbokspruit, although the land is not listed as environmentally sensitive in terms of GDARD's CPlan, and there are existing signs of degradation in the surroundings. Additional traffic due to the establishment of the LTS will be negligible.*

**Table 1: Summary of Reference Solutions**

LTS Reference Projects	Western Basin	Central Basin	Eastern Basin
DECANT			
Expected Primary (point source) Decants if Immediate Works and STI are not commissioning timeously			
Location	Black Reef Incline Shaft	Cinderella West Shaft	Nigel Shaft No. 3
Surface Level	1 669 m amsl	1 620 m amsl	1 549 m amsl
Possible Secondary (point source) Decants			
Location	No.'s 17 and 18 Winzes	Cinderella East Shaft and possibly other ERPM shafts Better low points along the southern edge of the basin	Nigel's No. 2 and 10 Shafts both at 1 559 m amsl, and Nigel's No. 7 and 13 and Sub Nigel B and CV Shafts, all at 1 558 m amsl. Decant may also occur in the north-eastern zone of the basin at Marievale No.'s 4 and 7 Shafts at 1 565 m amsl and 1 564 m amsl.
Surface Level	1 679 m amsl and 1 677 m amsl respectively	1 627 m amsl	
Other Possible Secondary (diffuse) Decants			
Location	N/A	Diffuse decant may also occur at unexpected locations where there are isolated compartments which are not connected to the main void.	
ABSTRACTION POINT			
Location	Rand Uranium No. 8 Shaft	South West Vertical Shaft	Grootvlei No. 3 Shaft
Collar Level	1 726 m amsl	1 646 m amsl	1 570 m amsl
Possible alternatives for abstraction	Mintails No. 9A or 9B Shaft (to be confirmed with Mintails)	• Multiple abstraction points (boreholes) strategically positioned throughout the basin, with good connectivity at shallow (and other depths). This	Marievale No. 5 Shaft (1 581 m amsl)

LTS Reference Projects	Western Basin	Central Basin	Eastern Basin
	Gravity tunnel if economic in future	<p>will reduce the risk from failure of a pump shaft due to collapse of the shaft itself or underground tunnels and is likely to result in a more rapid improvement in the pumped water quality.</p> <ul style="list-style-type: none"> <li>• Locate and protect ventilation shaft at SWV. This shaft was initially rejected because it is too small (diameter of 6 m) and is only connected to the void by a single tunnel. However, a single pump can be installed in the shaft and it is recommended that this shaft be located and protected.</li> </ul>	

WATER CONTROL LEVELS			
<b>Initial ECL (ECL-1)</b>	1 600 m amsl (Recommended for LTS, if not sufficient, revert to ECL-2)	-	1 280 m amsl (Conservative ECL, recommended initially)
Feature to protect	Dolomitic aquifer at approximately 1 610 m amsl	-	Base of dolomites of the Transvaal Supergroup at approximately 1 280 m amsl
Associated TOL (ECL-1)	1 585 m amsl	-	1 280 m amsl (same as ECL-1)
Static Pump Head at the recommended point of abstraction	141 m	-	290 m
<b>Possible Long-Term ECL (ECL-2)</b>	1 565 m amsl (Conservative ECL)	1 520 m amsl (Recommended for LTS)	1 470 m amsl (Recommended for LTS)
Feature to protect	Dolomitic aquifer (Conservative ECL, if ECL-1 is not sufficient)	Weathered / fractured aquifers to a depth of 100 m. The aquifers go deeper and abstraction from there may need to be curtailed.	Protect water use from aquifers to a depth of 100 m. This should ensure a positive head from the aquifer to the ECL.
Associated TOL (ECL-2)	1 550 m amsl	1 500 m amsl	1 450 m amsl
Static Pump Head at the recommended point of abstraction	176 m	146 m	120 m

<b>LTS Reference Projects</b>	<b>Western Basin</b>	<b>Central Basin</b>	<b>Eastern Basin</b>
<b>SECL-1</b>	N/A	1 474 m amsl	N/A
Feature to protect	N/A	Gold Reef City Level 5 Museum	N/A
Associated TOL (SECL-1)	N/A	1 454 m amsl	N/A
Static Pump Head at recommended point of abstraction	N/A	192 m	N/A
<b>SECL-2</b>	N/A	1 396 m amsl	N/A
Feature to protect	N/A	Mining to a depth of 250 m below surface at SWV	N/A
Associated TOL (SECL-2)	N/A	1 376 m amsl	N/A
Static Pump Head at the recommended point of abstraction	N/A	270 m	N/A
<b>SECL-3</b>	N/A	1 246 m amsl	N/A
Feature to protect	N/A	Mining to a depth of 400 m below surface at SWV	N/A
Associated TOL (SECL-3)	N/A	1 226 m amsl	N/A
Static Pump Head at the recommended point of abstraction	N/A	420 m	N/A

<b>ABSTRACTION PUMPING RATE</b>			
<b>Average</b>	23 Mℓ/ 24hrs	46 Mℓ/ 24hrs	80 Mℓ/ 24hrs
<b>Range</b>	19 – 27 Mℓ/ 24hrs	30 – 90 Mℓ/ 24hrs	70 – 100 Mℓ/ 24hrs

<b>TREATMENT</b>			
<b>Treatment location</b>	Approximately 1.5 km west of the abstraction point	Adjacent to the abstraction point	Adjacent to the abstraction point
<b>Ion Exchange</b>	CAPEX & OPEX included. Economic	CAPEX & OPEX included. Economic Cost-Benefit	CAPEX & OPEX included. Economic Cost-Benefit

<b>LTS Reference Projects</b>	<b>Western Basin</b>	<b>Central Basin</b>	<b>Eastern Basin</b>
	Cost-Benefit Analysis to be done during procurement by tenderers.	Analysis to be done during procurement by tenderers.	Analysis to be done during procurement by tenderers.
<b>Neutralisation</b>	HDS	HDS	HDS
<b>Desalination</b>	Conventional RO	Conventional RO	Conventional RO
<b>Possible alternatives for treatment</b>	After the initial 15 year DBOM, more cost effective technologies will be considered for implementation.	After the initial 15 year DBOM, more cost effective technologies will be considered for implementation.	After the initial 15 year DBOM, more cost effective technologies will be considered for implementation.

<b>BALANCING STORAGE</b>									
	<b>Time (hrs)</b>	<b>Volume (m<sup>3</sup>)</b>	<b>Type</b>	<b>Time (hrs)</b>	<b>Volume (m<sup>3</sup>)</b>	<b>Type</b>	<b>Time (hrs)</b>	<b>Volume (m<sup>3</sup>)</b>	<b>Type</b>
<b>Before treatment (Raw AMD)</b>	24	23	Lined Earth	24	46	Lined Earth	24	80	Lined Earth
<b>After treatment (Treated water)</b>	16	15 900	Reinforced Concrete	16	30 700	Reinforced Concrete	16	53 300	Reinforced Concrete

<b>APPLICATION OF AMD</b>			
<b>Options for Use/ Discharge of Water</b>	Supply to Rand Water's current and future industrial users. Pipeline to basin's boundary included in Reference Project. Further engagement with respect to clarifying the detail associated with the recommended off-take needs to commence.	Supply to Rand Water's current and future industrial users. Pipeline to basin's boundary included in Reference Project. Further engagement with respect to clarifying the detail associated with the recommended off-take needs to commence.	Supply to Rand Water's current and future industrial users. Pipeline to basin's boundary included in Reference Project. Further engagement with respect to clarifying the detail associated with the recommended off-take needs to commence.

<b>RESIDUE MANAGEMENT</b>			
<b>Sludge</b>	Waste disposal site identified approximately 2.5 km north of the proposed treatment works	Waste disposal site identified approximately 14.5 km south-east of proposed treatment works	Waste disposal identified approximately 2.5 km south-east of the proposed treatment works
<b>Brine</b>	Brine evaporation ponds adjacent to the	Brine evaporation ponds 2 km west of the treatment	Brine evaporation ponds identified approximately 3

	treatment site	site	km south-east of the proposed treatment works
<b>Possible Re-use/ Residue with a Commercial Value</b>	<p>Useful products recovered from the treatment process, particularly if ion exchange is included, may include:</p> <ul style="list-style-type: none"> <li>• Uranium recovery.</li> <li>• Metals recovery;</li> <li>• Supplements for mine land rehabilitation and re-vegetation;</li> <li>• Building- and construction-related materials, as used in gypsum boards;</li> <li>• Beneficial use of brine in the cultivation of halophilic organisms;</li> <li>• Recovery of saleable products such as sulphur and magnesium salts;</li> <li>• Agricultural use (e.g. fertilizer);</li> <li>• Supplements in cement manufacturing;</li> <li>• Metal adsorbents used in industrial wastewater treatment;</li> <li>• Pigment (ferrihydrite) for paints; and</li> </ul> <p>No re-use or recovery options have been recommended for the Reference Project, but any proposals received during implementation that includes such an option will be considered.</p>		

## COST AND ECONOMIC ASSESSMENT OF THE LTS

The capital costs of the LTS and lifecycle costs of the STI and LTS of the Reference Project for each basin are given in **Table 2**.

**Table 2: Summary of Reference Projects' Costs**

Description	Basin		
	Western	Central	Eastern
	R million		
CAPITAL COSTS (CAPEX) – LTS	1 410	2 280	2 970
Grand Total for CAPEX	6 660		
Average Annual O&M and Lifecycle Costs (OPEX) – STI and LTS	230	330	430
Grand Total for OPEX	990		

An assessment of the economic benefits of implementing the LTS for AMD in the Western, Central and Eastern Basins was undertaken. It was found that the implementation of the LTS for AMD and the required expenditure will have significant positive economic benefits for the region, contributing a total of 16 677 million to the GDP (construction, operation, maintenance and equipment overhaul), creating more than 32 000 temporary and about 4 000 long-term employment opportunities.

## LEGAL DUE DILIGENCE

A due diligence assessment was conducted to identify any legal or regulatory issues that might negatively affect the project. No problems were identified and the following legislation will have to be taken into consideration:

- Constitution of the Republic of South Africa, 1996;
- National Water Act, 1998 (Act No. 36 of 1998) (NWA (36:1998));
- National Environment Management Act, 1998 (Act No. 107 of 1998) (NEMA (107:1998));
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA and subsequent regulations(28:2002));
- Promotion of Administrative Justice Act, 2000 (Act No. 3 of 2000) (PAJA (3:2000));
- Government Finance (such as the Public Finance Management Act, 1999 (Act No. 1 of 1999) (PFMA((1:1999)) and Procurement-related Legislation;
- Mine Health and Safety Act, 1996 (Act No. 29 of 1996) (MHSA (29:1996));
- Town planning and land use ordinances;
- Disaster Management Act, 2002 (Act No. 57 of 2002) (DMA (57:2002));
- Deeds Registries Act, 1937 (Act No. 47 of 1937) (DRA (47:1937));
- Land Survey Act, 1997 (Act No. 8 of 1997) (LSA (8:1997));



- Companies Act, 2008 (Act No. 71 of 2008); and
- Government Immovable Asset Management Act, 2007 (Act No. 19 of 2007)

## **INSTITUTIONAL PROCUREMENT AND FUNDING MODELS**

*A Procurement Options Analysis was conducted to select the procurement methodology that best achieves the procurement objectives for the LTS. The recommended model includes the successful bidder taking over, maintaining and operating the infrastructure of the STI, once the LTS is commissioned. The preferred contracting model will be one where the operations, supply and installation of technology, design, construction and maintenance are integrated and provided by a single entity with minimum risk to Government for the minimum cost for the duration of the contract in a sustainable manner and with an enduring positive legacy.*

*The identified models that meet the objectives are either a Design, Build, Operate and Maintain (DBOM) model with the contract being agreed with a single Service Provider; or a Design, Build, Operate, Maintain and Finance (DBOMF) (PPP) model, with the private sector providing some or all of the funding. The traditional structure of an Employer Design, Procure, Construct and Operate contract was used as a base case for comparison.*

*The institutional options available for the Department to procure and manage the development and operational phases are to:*

- *Manage the project directly, using resources from within the Department supported by a Professional Service Provider (PSP);*
- *Delegate responsibility through a suitable contract to a managing agent sourced either from a Public Entity or from the Private Sector; or*
- *Appoint a Public Entity as the Implementing Agent (IA) which would contract with the Service Provider directly on behalf of the Department.*

*The DWA have advised that they intend directing TCTA to implement the LTS as the IA, through a DBOM contract.*

## **ENVIRONMENT FOR IMPLEMENTATION**

### **Water Quantity and Quality**

*The premise is that AMD from the Western, Central and Eastern Basins will need to be managed forever. Long-term planning will have to take into account that the ECL and SECL may need to be adjusted as the effect of pumping is monitored. The TOL and pumping head is likely to change as the hydraulic gradient of the abstraction points will vary with time. The quantity and quality of the water to be managed will vary with time. These uncertainties can only be reduced once pumping has been under way long enough for steady state conditions to be established and suitable monitoring programmes have been in place for a number of years.*

*The realistic life of most of the infrastructure required will be 50 years or less. Many mechanical components require significant maintenance and may need to be replaced at regular intervals. Operation and Maintenance (O&M) contracts with a minimum period of five years are recommended, but 10 years to 15 years would be preferable to allow the recovery of start-up costs.*

### **Costs and Treatment Technologies**

*The annual operating and scheduled overhaul and replacement costs for the LTS and STI together are expected to be about 15% of the capital cost. Pumping costs are expected to be about 15% to 25% of the total operating costs. The cost effectiveness of measures to reduce ingress should be evaluated against the pumping and treatment costs. The cost of adequate monitoring to allow the TOL to be optimised will be small compared to the cost of pumping.*

*The only technologies which have been proven for treating AMD are HDS followed by conventional RO, with Ion Exchange for the extraction of Uranium. Between 15% and 20% of the annual operating costs are for the disposal of the sludge from the HDS and RO processes.*

*Mining companies are reclaiming the gold in old mine dumps, and Mintails is testing a process that uses raw AMD in their tailings treatment process. This process uses less chemicals than HDS and produces a waste product that can be disposed of on a Tailings Storage Facility (TSF), but there are uncertainties about the fate of some chemicals and the Uranium. Any treatment processes that can reduce the operating costs and waste disposal will have significant economic benefits.*

### **Principles for Implementation**

*The following principles for planning implementation were adopted:*

- *The LTS should limit capital investment in long-term infrastructure that may become obsolete because new processes with lower lifetime costs become available;*
- *Implementation of the LTS should be phased with a medium term phase not exceeding 15 years and long-term phases to follow;*
- *The LTS should not unnecessarily sterilise access to mineral resources;*
- *If Government is to fund the solution, only technologies that Government considers to be proven should be accepted;*
- *If Private Sector finance is allowed, then technologies that the banks consider proven can be considered. The possibility of the Private Sector being prepared to fund technologies that are currently at the pilot stage of development, or are used at large scale elsewhere in the world under different conditions, should be considered;*
- *Any opportunities to link AMD treatment with parallel initiatives, such as the removal of mine dumps and land rehabilitation to reduce pollution, the treatment of urban waste*

*water or the use of waste products from waste treatment or industrial processes, should be explored during implementation;*

- *Opportunities should be provided for unproven technologies, with the potential to treat AMD to acceptable standards and at lower operating cost, to prove their viability;*
- *Government should support the development of technologies since they will have long-term benefits for the country in the management of AMD, not only on the Witwatersrand; and*
- *Opportunities should be used to introduce new technologies with lower operating costs without introducing unacceptable risks.*

## **RECOMMENDATIONS FOR IMPLEMENTATION**

*The LTS concurred with the STI that HDS is the only proven technology for neutralisation of AMD, but the ideal situation is that, in the long-term, neutralisation and the removal of heavy metals should form part of an integrated process procured under a (DBOM) contract, including neutralisation and desalination.*

*The following proposals are made for implementation in each basin in the medium and long-term:*

### **Western Basin**

*The Immediate Works has stabilised the situation, and there is thus no immediate urgency to implement the HDS plant proposed by the STI. There is time to plan the procurement of an integrated treatment process through a DBOM contract, but a medium-term solution is required until the decision is taken to implement an integrated LTS. The following recommendations are made for the medium-term solution:*

- *The ECL of 1 600 m amsl and TOL of 1 585 m amsl should be implemented and monitored.*
- *This Study concurs with the STI that if proved stable Rand Uranium Shaft No. 8 should be used for the LTS. If not stable nearby alternatives should be considered.*
- *The STI pumps should pump at the full capacity of the treatment works to draw down the water level in the mine void to the TOL. Thereafter, pumping should be maintained at a constant 23 Mℓ/d. The water level in the void should be monitored and the pumping rate adjusted if necessary.*
- *Ingress areas have been identified and communicated to the relevant authorities, particularly the large open pits at West Wits Pit (WWP) and Millsite. There is support for licensing the disposal of tailings into these pits, and it is recommended that closure plans for these operations include final shaping and capping of the tailings deposits to prevent ingress of water to the mine void. Mintails is developing a methodology for sealing the WWP.*

- *Pre-treatment for neutralisation and metals removal will be required until the LTS is implemented. The possibilities include operating the Gold One plant, which is currently being upgraded by TCTA, for as long as possible after the Pilot Treatment Plant phase, with further upgrade through the addition of a clarifier. Alternatively, use the process proposed by Mintails of combining raw AMD with tailings from their gold extraction process in a Tailings Water Treatment (TWT) process, with Mintails managing the resulting residues. The Mintails neutralisation process could possibly be operated for as long as 30 years and would eliminate the need for adding a clarifier to the Gold One plant.*
- *In the Reference Solution, desalination would have been by RO, but it is proposed that, the Western Basin be used to test promising but unproven technologies in a number of Pilot Treatment Plants, each with a capacity of between 5 and 10 Mℓ/d (preferably at least 8 Mℓ/d). Three or more such plants could treat the long-term average of 23 Mℓ/d, while four plants of 10 Mℓ/d would be required to treat the 40 Mℓ/d that is likely to be abstracted until the TOL is reached. These Pilot Treatment Plants should operate for 5 to 10 years, after which successful technologies should have been identified and can be commissioned. The Water Research Commission should be the lead agency for procuring, managing and testing the Pilot Treatment Plants, supported by DWA and the Department of Science and Technology (DST).*
- *Because of the unproven nature of these technologies, some of the treated water may not meet the specifications for potable or industrial water. The treated water will always be at least neutralised and generally have significantly lower salinity than the neutralised water. The treated water could be discharged to the Tweelopies Spruit until water of a consistent and acceptable quality is produced that could be supplied to users.*
- *The main residues will be sludge from the gold-recovery and neutralisation plants and Pilot Treatment Plant process, and brine from the Pilot Treatment Plant process. It is unlikely in the medium term that the residues would have commercial value. If the Mintails TWT process is adopted, Mintails would manage the residues from that process, and only the residues from the Pilot Treatment Plant (primarily sludge and brine) would have to be managed.*
  - *Sludge: TCTA has an agreement with Mogale Gold to discharge sludge from the Immediate Works neutralisation plant into the WWP via a settling dam. It is recommended that an extended agreement should be negotiated with Mintails for the discharge of sludge or other residues into the WWP. Mintails will only be able to consider accepting sludge from the Pilot Treatment Plants until about 2018 when the pit will be full. If Mintails will not accept sludge from the Pilot Treatment Plants, an alternative possibility would be co-disposal with the Mogale Gold tailings on their proposed new TSF. The only other alternative would be a new SSF which will be required in due course as part of the LTS. The nature of the sludge from the Pilot Treatment Plants is unknown, but it has been assumed that the solids will not settle and it will be unsuitable for constructing the perimeter wall of the SSF; waste rock will*

*thus need to be imported. It is assumed that the sludge will be classified as hazardous. The site must therefore be lined, and a leachate management system will be required.*

- Brine: Construction of the proposed LTS brine disposal facility is recommended, including evaporation ponds, which are low tech and have low operating costs.*
- On-going research initiatives into the management of AMD should be encouraged, including WRC-supported research initiatives on the BIOSURE process and use of neutralised AMD for irrigation as part of a long-term neutralised AMD management strategy in the Vaal Basin.*

#### *Proposals for Implementation for the Long-Term*

*In an attempt to identify an option for abstraction that would avoid the high electricity costs associated with pumping the AMD up a shaft, Study Report No. 5 considered the option of constructing a tunnel from just below the TOL to discharge by gravity. The most feasible option would be a 7.5 km long tunnel that would surface close to the Percy Steward WWTWs. This would have had particular advantages if a biological treatment process was to be adopted, or if the treated water was to be supplied to users below this level and in the vicinity, or discharged to the local stream. The tunnel option is not recommended in the medium-term, but should be reconsidered when it has been decided whether or not the Mintails' TWT forms part of the solution, and whether the biological treatment process is viable, and after end-users for the water have been confirmed.*

*However, because the treated water will probably be supplied to industrial users, possibly some distance away, the electrical energy used to raise the water up the shaft will not be wasted as it will contribute to the energy required to convey the treated water. There would then be no cost saving to offset the high construction cost of the tunnel or of the STI infrastructure, particularly the pumps at the shaft, which would become redundant.*

*The tunnel option is therefore not recommended in the medium-term, but should be reconsidered when it has been decided:*

- Whether or not the Mintails' TWT forms part of the solution;*
- End-users for the water are confirmed; and*
- Whether the biological treatment process is technically and economically viable with suitable sources of organic material.*

*Further investigations should be commenced in about 2016 when these factors are known.*

*If conditions for gravity abstraction are not favourable or further studies show it to be uneconomic, a new DBOM or DBOMF (PPP) tender for the required treatment, residue management and infrastructure for treated water should be procured.*



## **Central Basin**

*The proposals for implementation are divided into two phases, medium-term for the next 15 years, using currently proven technologies, and a long-term phase for the period after that.*

*The recommended ECL is 1 520 m amsl with a long-term TOL of 1 500 m amsl, with an initial TOL of 1 470 m amsl. By the time the STI is commissioned, the water level in the void is expected to be at about 1 495 m amsl (i.e. a freeboard of 25 m); the water level should then be lowered to 1 470 m amsl to give an initial freeboard of 50 m below ECL of 1 520 m amsl so that the behaviour of the void can be monitored without risking breaching the ECL. The freeboard and thus the TOL to protect the ECL should be adjusted in future, based on the monitoring of the water levels in the void across the basin.*

*It is recommended that abstraction be from the SWV Shaft.*

*However, to mitigate the risk that the effectiveness of abstraction at the SWV Shaft may at some time be reduced, additional abstraction strategies have been identified. Detailed investigations should commence as soon as possible so that a contingency plan is available. They are described in more detail in Chapter 2.*

- *The pumps procured for the STI can pump the volume of 46 Mℓ per 19-hour day, or 58 Mℓ per 24-hour day, which is anticipated to be required and can pump from the required depth range of possible shallower depths and should be used.*
- *The 46 Mℓ/19-hour day HDS plant being constructed and commissioned by TCTA should be used for at least the medium-term (15 years).*
- *If a DBOM contract is used, then it is recommended that the specifications require a proven technology for desalination, and it is anticipated that RO will be the core of most tenders on acceptable technologies could include others for which the Private Sector will take the technical and financial risk.*
- *The inclusion of Ion Exchange technology by any tenderer is likely to be based on economics.*
- *It is recommended that the water be treated to a suitable standard and supplied to Rand Water who has current and potential industrial consumers to whom they will be able to sell the full volume of treated water from the basin.*
- *For the STI, the neutralised sludge was to be pumped to the existing ERGO regional TSF for co-disposal with their tailings. However, this is no longer the intention and alternatives are being investigated. The desalination plant will produce a similar volume of sludge as the HDS plant and the STI planning should allow for this volume.*
- *Purpose built brine evaporation ponds should be constructed.*
- *Requests from research institutions for batch samples or small flows of AMD at various stages of treatment should be accommodated wherever possible, in order to develop more viable technologies.*

- RO package plants could possibly be installed and commissioned downstream of the HDS plant in less than 12 months, which would reduce the salt load in the Vaal River System and the risk of water restrictions from 2015, possibly 24 months before the LTS can be commissioned. DWA should direct TCTA to conduct a cost–benefit assessment of the use of package plants.

*In the longer term, depending on the success of the Pilot Treatment Plants proposed for the Western Basin, the possibility of other treatment options with lower operating costs, and ideally producing less waste, should be considered.*

*A new DBOM or DBOMF (PPP) contract should be procured in sufficient time for it to be Ready for Operation (RfO) before the expiry of the medium-term contract.*

*The bidders would be free to use the medium-term works should they so desire.*

### **Eastern Basin**

- *A conservative ECL of 1 280 m amsl has been recommended for initial use. It is estimated that this level will be reached by rising AMD by mid-2014, but the STI will probably only be commissioned in December 2014. It is recommended that, if adequate monitoring of the dolomitic aquifer is in place, the water level be held at the level which has been reached at the time the STI is RfO, provided that it is below TOL-1 of 1 450 m amsl (i.e. the water level at the time of RfO is adopted as the initial TOL).*
- *If adequate monitoring of the water quality in the dolomite has been established, and no pollution is observed at the ECL of 1 280 m amsl (associated TOL also 1 280 m amsl), the water level can be allowed to rise, possibly as high as 1 450 m amsl, provided that no AMD pollution is detected. No SECL is currently set for the Eastern Basin.*
- *Grootvlei No. 3 Shaft should be used for abstraction.*
- *Should an unforeseen problem arise with abstraction at this shaft, alternatives would need to be considered and Marievale No. 5 Shaft which is connected to both the Kimberley Reef and the Nigel (Main) Reef via haulages is the recommended alternative.*
- *The mine void water level monitoring has shown that the water levels in the areas of sporadic mining vary independently of the water level in the main void. Additional abstraction sites may need to be identified and abstraction and treatment implemented.*
- *Pumps procured as part of the STI, with capacity of 80 Mℓ per 19-hour day, and 100 Mℓ per 24-hour day, should be retained as part of the LTS.*
- *The HDS neutralisation plant with an average capacity of 80 Mℓ/19-hour day will be used.*
- *The specifications for the proposed DBOM or DBOMF (PPP) contract require a proven technology for desalination, and it is anticipated that RO will be the core of most tenders.*
- *The inclusion of Ion Exchange technology by any tenderer is likely to be based on economics. Secondary treatment could comprise chlorination, depending on the user.*

- *The water be treated to a suitable standard and supplied to Rand Water who has advised that they have current and potential industrial consumers to whom they will be able to sell the full volume of treated water from the basin as soon as possible. The required quality will depend on the users and their application.*

*The main residues are expected to be sludge from the HDS plant and RO process, and brine from the RO process.*

- *It is proposed that the STI construct a stand-alone SSF to accommodate both HDS and RO sludge on the site identified by the LTS.*
- *Separate brine evaporation ponds should be constructed.*

*In the Longer Term it is recommended that a new DBOM or DBOMF (PPP) contract be procured in sufficient time for it to be RfO before the expiry of the medium-term contract.*

*The bidders would be free to use the medium-term works should they so desire.*

*It will be important to ensure that water level recorders and water quality sampling points are established and monitored at enough points across each basin to provide sufficient data to determine the hydraulic gradient and changes in void water quality. This information, together with the data from the operation of the STI and the LTS, should be continually assessed to optimise the operation of the works, and then used for the design of the next phase of the LTS.*

## **IMPLEMENTATION STRATEGY**

### **Cost Recovery and Revenue Collection**

*The polluter and user pay principles form the underlying basis for recovering the capital and operating costs of the LTS and the operating costs of the STI, which will be incorporated into the LTS. However, the Department may fund some of the costs from its annual operating budget.*

*The opportunities for cost recovery are:*

- *Polluters pay:*
  - *Cost recovery from mines;*
  - *Contributions from mines' Trust Funds;*
  - *Cost recovery from the Waste Discharge Charge System (WDCS); and*
  - *Cost recovery from a possible future Environmental Levy or mining tax (to be investigated).*
- *It is recommended that an Inter-Departmental Legal Task Team be established to engage with the mines. The pilot work on the WDCS should inform how it can best be used.*
- *Beneficiaries and users pay:*



- *Cost recovery from the Vaal River Tariff (VRT) (most likely only applicable to Central and Eastern Basins, since abstraction location of Western Basin AMD is within Crocodile (West) River Water Management Area).*
- *Income from the sale of raw AMD water to Mintails; and*
- *Sale of treated water to Rand Water.*
- *Other possible income streams are from the sale of residue products with a commercial value, including iron, Uranium and gypsum.*

*The amounts that will be recovered from the mines and the timing are too uncertain to be relied on in planning. The funding required to pay interest and redemption on any capital loans and to cover the annual operating costs, which will include a maintenance reserve account to provide for major maintenance, refurbishment and replacement requirements, will thus, at least initially, come from a combination of the VRT, the WDCCS and National Treasury through the Department's annual budget.*

*The Department should be responsible for all cost recovery activities, except for the minor and uncertain revenue generated from the sale of waste products which should be the responsibility of the operator and for which some form of profit sharing could be agreed.*

### **Procurement Methodology and Process**

*Procurement will be a two-stage process, in which the first stage will be a qualification stage to achieve a shortlist of pre-qualified bidders through a Request for Qualification (RfQ), and the second stage will be a Request for Proposals (RfP) from shortlisted bidders.*

*Conventional procurement uses input specifications and specifies the inputs required to achieve the required outcome. In the procurement of a DBOM or DBOMF contract, however, the procurement and contract documentation specifies the output that has to be achieved – the delivery of treated water to a certain specification. The concept of output specifications would entail a change in how the Department views the delivery of its services. Instead of procuring infrastructure, the Department would consider procuring the service with specified outputs, and the performance of the contracted operator would be monitored on an on-going basis.*

*Non-recourse funding or limited recourse loan funding could be used for project financing. South African banks are signatories to the Equator Principles, which requires them to ensure that the projects that they finance are socially responsible and reflect sound environmental management practices.*

### **Procurement Plan for the Western Basin**

*The Western Basin will be used to procure a number of service providers with an emerging technology that has been shown to work, but not at the scale required to treat AMD in the Witwatersrand gold-mining basins. A competitive procurement process would be used to identify the technologies with the best chance of commercially treating AMD in a cost-efficient manner. It is expected that up to four Pilot Treatment Plants will be procured, funded*

through a combination of capital funding from the Department of Science and Technology (DST), DWA, WRC and Private Sector investors. It is recommended that the WRC be the lead agency for procuring, managing and testing the Pilot Treatment Plants, supported by DWA and DST. The contract will be an output-based contract requiring the bidders to propose a Pilot Treatment Plant solution. The Pilot Treatment Plants will be contracted for up to 10 years, after which proven technologies will be encouraged to bid on the long-term contracts for the Western Basin and later, Eastern and Central Basins.

In addition, ancillary works will need to be provided under a separate contract.

The Form of Contract for the pilot projects will be a standard WRC research contract with purpose-designed financial arrangements.

The scope of the contract would include:

- Providing a balancing reservoir and associated pumps and pipelines between the neutralisation plant and the reservoir;
- Providing the infrastructure to receive the residue streams from each Pilot Treatment Plant; and
- Providing the infrastructure required (e.g. SSF and brine evaporation ponds to manage the residues).

The residue management facilities should be planned to manage the residues from a desalination process for 45 years, but the construction of the SSF should be phased.

### **Procurement Plan for the Central and Eastern Basins**

The contract in the Central and Eastern Basins should be either a DBOM or DBOMF (PPP), as decided by DWA.

There would be a separate contract with separate service providers per basin, given their varying sizes and differing raw water qualities. There will be no constraint on the same bidder being successful in the Central and/or Eastern Basins and also having a pilot technology in the Western Basin.

The Scope of Work (SoW) is summarised as follows:

- Take-over, operate, maintain and, where required, refurbish and replace components of the STI;
- Design and construct the infrastructure, technology and operating process to treat raw AMD and manage the residues from the full process. It would be expected, but not required, that the STI infrastructure would be incorporated into the LTS, in which case, the new treatment works would be for desalination. Should the STI not be incorporated into the LTS, then provision will be made for mothballing the components of the STI that are not required. The mothballing will be such that the mothballed plant can be re-commissioned on the expiry of the contract should the need arise;

- *Construct the infrastructure that has been designed, and supply the required technology equipment and all associated plant and equipment;*
- *Commission the supplied plant and constructed infrastructure;*
- *Integrate the STI into the LTS and balance the system so that a continuous flow of treated AMD is achieved with the designed percentage or less of waste and brine;*
- *Operate all the works and residue management facilities for the duration of the contract, providing and being reimbursed for producing treated water from the raw AMD;*
- *Where possible, produce residues with a market value and a market, and sell these in an accountable and transparent manner;*
- *At about three years from the expiry of the contract, support the Department in securing a replacement Service Provider contract;*
- *At or about two years from the expiry of the contract, undertake a dilapidation survey of the project assets; and*
- *If required on expiry of the contract, hand the operational facility over to DWA.*

*The LTS for the treatment of AMD will need contracts for the foreseeable future, say 100 years. Shorter-term contracts would be preferable to a long-term contract. A 15-year operational contract is proposed, which sufficiently long to minimise the annual capital repayment and sufficiently short that a new technology that would reduce the operational costs, can be acquired before too long.*

### **Approach to Broad-Based Black Economic Empowerment**

*The involvement of Black Economic Empowerment (BEE) companies and individuals will be achieved through appropriate wording in the procurement documentation and contract agreements, and the execution of the requirements will be monitored by the Performance Monitoring Team in each of the three basins.*

### **Contract Management**

*During the closing stages of negotiations, DWA or its IA will need to draft a Contract Management Plan (CMP) to assist the Department in developing a good working relationship with the contracted service provider to achieve the objectives of the Project. The CMP will include monitoring of the design, selection and procurement of the selected technology, construction of infrastructure, installation of plant and equipment. When this is complete, the works will be certified as Ready for Commissioning (RfC); once commissioning has been completed, the LTS and integrated STI infrastructure can be certified as RfO.*

### **RISK MANAGEMENT**

*The technical risk should be transferred to the Private Sector as far as possible, preferably through a DBOMF (PPP) contract. Transferring risk incurs a cost, but the Value for Money Assessment (VMA) has shown this approach to be marginally more cost effective.*

*A detailed risk assessment of all the elements of the Reference Project for each basin was conducted and a mitigation strategy was identified for each risk.*

*In the Implementation Phase, a detailed Risk Management Plan will be prepared as part of the Contract Management Plan.*

*Risks to the reputation or credibility of DWA must be managed by the Department. Where risks are from areas that are the responsibility of other National or Provincial Governments or Local Authorities, these departments must be aware of their responsibilities and be held accountable by the Intra-Governmental Task Team (IGTT) and Inter-Ministerial Committee (IMC).*

### **Parallel Implementation Activities**

*The acquisition of land, or the right of access to land, and the completion of an environmental impact assessment (EIA) are required before contracts can be covered.*

### **Operation and Maintenance Phase**

*The O&M Phase commences once the works are Ready for Operation (RfO). DWA will retain overall responsibility in this phase, although they may use an IA or Contract Management team to ensure that the conditions of the DBOM or DBOMF (PPP) contract are adhered to.*

### **Organisational Structure for Implementation**

*The lead organisation will be DWA but DMR, DEA, TCTA, Rand Water and Local Authorities will all be important role players. The Special Project Unit (SPU), recommended to be established by DWA, should be responsible for ensuring that all organisations fulfil their responsibilities timeously.*

*The following are the priority actions for DWA to establish and resource the required organisational structure.*

- *Agree on institutional arrangements and responsibilities;*
- *Establish an SPU and define its responsibilities;*
- *Confirm that the form of contract to be used is a DBOM;*
- *Appoint the Head of the SPU;*
- *Issue Directives to Public Entities, as necessary; and*
- *Appoint a Professional Service Provider (PSP) team to support the SPU.*

### **Implementation Programme**

*The implementation programme is based on the following assumptions:*

- *DWA will establish a Special Project Unit (SPU) to be responsible for all the activities required for implementation;*

- The SPU will appoint a PSP to assist in fulfilling their responsibilities and their coordination role;
- DWA has decided to use a DBOM contract and not the Public Sector Comparator (PSC) or DBOM(F) alternatives; and
- DWA will direct TCTA to be the IA for the procurement of the DBOM contract and to carry out the EIA, and land acquisition for the LTS.

For all three basins, the critical activities are:

- The Department approving this Feasibility Study;
- The Department deciding on its internal organisational structure and responsibilities for implementation;
- The Department establishing the SPU;
- The Department deciding on the funding and cost-recovery plans.
- The Department submitting the Feasibility Study with their organisational structure for implementation, and the funding and cost-recovery plan, to NT;
- NT agreeing the funding and cost recovery plans;
- The Department issuing directives to TCTA to:
  - Procure a DBOM contract for the implementation of the LTS in the Central and Eastern Basins;
  - Procure the land required for the LTS; and
  - Carry out the required EIA.
- The Department concluding a Memorandum of Understanding (MoU) with Rand Water in terms of which they will buy the treated water at the treatment works.

If started timeously, the EIA can be completed, in parallel with the procurement process, with authorisation being received before financial close.

### **Evaluation of Impacts and Benefits of the Implementation**

The STI and LTS are being implemented to achieve the objectives of protecting the ECLs and/or SECLs; and limiting the impact of the solutions on the environment.

There are a number of unknowns that affect implementation, including:

- Whether the ECLs/SECLs can be raised, thereby saving costs while still protecting the environment and socio-economic assets, or whether they must be lowered to achieve the objective;
- How the water quality of the water abstracted from the void will change over time;
- How the water level in the void will vary across each basin; and
- The volume of water that will have to be pumped to maintain the applicable TOLs and whether the proposed TOLs are far enough below the ECL/SECL to protect these levels.



*The proposed monitoring programme will provide information that will enable the unknowns to be evaluated. That information, together with operational information from the STI and LTS, must be assessed and evaluated with the objective of making regular recommendations for refined operating procedures or monitoring.*

*The effective management of the three mine basins requires a dedicated team to assess all the monitoring information to ensure the effectiveness of the STI and LTS as well as plan further interventions and adjustments to the operations. This can only be achieved if a team, which has sufficient knowledge and resources to support integration between water resources managers and well-maintained databases, is tasked with this work. There will be considerable interaction with the IA and they could be tasked with these responsibilities.*

## **OTHER REQUIREMENTS FOR SUCCESSFUL MANAGEMENT OF AMD**

### **Hydrological and Geological Monitoring**

*The successful management of AMD in the mine voids of the three mine basins requires a dedicated, comprehensive and integrated monitoring and assessment programme. This could be achieved by sustaining and expanding the programme and capacity of the Wits AMD Hydrological Monitoring Committee (HMC) to support integration between water resource managers and well-maintained databases.*

*The objectives of the hydrogeological monitoring of the mine voids are to:*

- *Assess whether the implementation of the STI and LTS is achieving their objectives;*
- *Provide early warning of possible problems and identify areas where new interventions are required for effective management of the AMD in the mine voids;*
- *Provide data to assist in assessing the effectiveness of the ingress control measures that have been implemented; and*
- *Refine current understanding of the response of the void water to rainfall. Monitoring of surface water and near-surface aquifers (groundwater) is required so that the reasons for any changes in the quantity and quality of surface and groundwater can be understood and any problems can be addressed. In basins where the ECL determines the TOL, monitoring is essential to assess any impacts of the void water on the groundwater and allow the ECL to be optimised.*

*Monitoring is especially necessary during the initial phases of pumping so as to establish the hydrogeological parameters of the void. On-going monitoring is necessary to provide information on changes in connectivity of the compartments, for example due to collapse in the void. Improved water quality monitoring of near surface aquifers is required to detect any pollution from AMD.*

*Adequate spatial distribution of rainfall stations is required to correlate rainfall with ingress. The current South African Weather Services' coverage will need to be extended, and the stations should be real-time units.*

*Increased spatial distribution of surface water quantity and quality monitoring is also important to detect any impacts of AMD. The stability of the dolomites in the Western Basin must be investigated and monitored.*

### **Key Stakeholder Engagement and Communication**

*AMD management is a complex and multifaceted challenge requiring inputs from a wide range of stakeholders to ensure a sustainable LTS. Effective engagement and communication with stakeholders and the public is a key component of managing AMD.*

*The communication strategy should seek to harness the collective wisdom towards finding an LTS to the AMD challenge; and communicate sufficient and correct information to raise public awareness of the initiatives that are underway, their progress and benefits.*

### **Rehabilitation of Rivers**

*The rehabilitation of rivers affected by AMD will take place through source controls and various mitigation measures.*

*Although the STI has resulted in improved water quality, especially in the Western Basin, the current discharge of neutralised AMD with elevated salt levels is still causing impacts that will have to be managed appropriately through the LTS.*

*River rehabilitation will require authorisation in terms of NEMA (107:1998) and the NWA (36:1998) and will therefore be done in the context of Integrated Environmental Management.*

*The remediation of prior impacts caused by AMD should only be done after the implementation of the LTS (the LTS can therefore be seen to be part of the rehabilitation process), when the water quality, and the amount and velocity of runoff in the river are set.*

*The cost of rehabilitation should be considered as part of the LTS, and the possibility of cost recovery from the mines should be included in the negotiations on cost recovery for the LTS, particularly in the Western Basin, where the focus will be on the reparation of the effects of past uncontrolled AMD decant, and the current effects of saline discharges by the STI.*

### **Important Supplementary Initiatives**

*Significant investments will be necessary to construct and operate the LTS. It is therefore crucial to find ways to reduce the costs of managing AMD by implementing technologies that can achieve the same objectives at lower costs, or by reducing the volume of water to be pumped and treated.*

*Keeping clean water clean (i.e. preventing unpolluted surface water from entering the mine voids and becoming acidic), and preventing as much ingress of any water as possible, is one of the most cost-effective management measures.*

*The measures investigated by the DMR, through CGS, to reduce ingress into all three basins should be implemented, as a matter of urgency and on-going investigations should be expected.*

*GDARD has embarked on an initiative to enable the reclamation of mine residue areas for beneficial use. Reclamation is expected to have a significant positive effect on AMD pollution from mine dumps.*

## **RECOMMENDATIONS FOR A NATIONAL AMD STRATEGY**

### **Changes in Legislation**

*Proposed legislative amendments should be considered for incorporation into a National AMD Strategy, with the aim of enabling Government to have enhanced control and legal administration of the AMD challenges and issues and to give more clarity on responsibilities and obligations. This should not only apply after mine closure but should also enable Government to require pro-active steps long before mine closure.*

### **Studies**

*DWA should conduct studies for different mining areas to ensure that possible AMD challenges will be better understood and managed in future. The studies need to be managed as an inter-departmental initiative with collaboration with all relevant Departments, and to inform mine authorisations and the plans of individual mines.*

### **Trust Funds for Rehabilitation**

*Increasing the trust funds that mines provide for rehabilitation should be considered in order to provide for funding the capital and continued operational costs of managing AMD after mine closure.*

### **Mine Closure Plans**

*The stronger enforcement of mine closure plans needs to be further considered as an action for inclusion in the National Strategy.*

### **Creation of a National AMD Trust Fund**

*As a longer-term strategy, the feasibility of the establishment of a National Trust Fund, where all mines contribute towards the prevention, treatment and management of current mining activities, as well as the rehabilitation of the legacy of AMD, should be investigated. This should happen in close consultation with the Chamber of Mines and needs to be investigated in conjunction with consideration of an Environmental Levy, which could become a source of revenue for the Trust Fund.*



## **CONCLUSIONS**

*This Study has assessed and quantified the AMD problem from the Witwatersrand underground mining basins. Numerous options for abstraction water use, treatment and residue management have been integrated from possible solutions for each basin. These were assessed to develop a low risk preferred solution for each basin, for which concept designs were developed and costed. A range of approaches to procurement and funding, together with institutional arrangements were assessed and an implementation strategy has been developed. That, together with the complementary and supplementary activities has provided a sound basis for managing AMD on the Witwatersrand.*



# Table of contents

<b>1.</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	Background.....	1
1.2	This Report.....	2
<b>2.</b>	<b>NEEDS ASSESSMENT .....</b>	<b>5</b>
2.1	Hydrogeological Assessment .....	5
2.1.1	Introduction.....	5
2.1.2	Critical Water Levels.....	5
2.1.3	Surface Water Ingress .....	9
2.1.4	Water Quality .....	10
2.1.5	Selection of Locations for Abstraction .....	13
2.2	Design Capacity of Pumps and Treatment Works.....	16
2.3	Summary of Recommendations.....	17
<b>3.</b>	<b>OPTIONS FOR A LONG-TERM SOLUTION .....</b>	<b>19</b>
3.1	Introduction .....	19
3.2	Options for Use or Discharge of Water .....	19
3.2.1	Introduction.....	19
3.2.2	Cost–Benefit Analysis of Alternative Water Resource Management Scenarios for the Vaal River System .....	20
3.2.3	Water Resource Management Scenarios for the Crocodile (West) River System .....	22
3.2.4	Options for Use or Discharge of Water .....	23
3.3	Assessment of Technologies for the Treatment of AMD .....	26
3.4	Options for the Sustainable Management or Use of Residue Products .....	29
3.4.1	Introduction.....	29
3.4.2	Sludge .....	29
3.4.3	Brine .....	31
3.5	Summary of Options.....	31
<b>4.</b>	<b>PREFEASIBILITY SELECTION OF OPTIONS FOR FEASIBILITY LEVEL ASSESSMENT .....</b>	<b>33</b>
4.1	Introduction .....	33
4.2	Approach to Economic Assessment of Selected Options.....	34
4.3	Assessment of Selected Options for the Western Basin .....	35
4.3.1	Desalination and Release to River .....	35
4.3.2	Desalination for Domestic or Local Industrial Use .....	36
4.3.3	Desalination for Industrial Use at Marikana .....	37
4.3.4	Tunnel with Desalination and Release to River .....	38
4.4	Assessment of Selected Options – Central Basin .....	40
4.4.1	Desalination and Release to River .....	40
4.4.2	Desalination for Domestic or Local Industrial Use .....	41
4.4.3	Desalination for Industrial Use at Secunda.....	42
4.4.4	Tunnel with Desalination and Release to River .....	44
4.4.5	Tunnel with Desalination for Domestic or Industrial Use.....	45
4.4.6	Multiple Boreholes for Abstraction.....	46
4.5	Assessment of Selected Options – Eastern Basin .....	47
4.5.1	Desalination and Release to River .....	47
4.5.2	Desalination for Domestic or Local Industrial Use .....	48
4.5.3	Desalination for Industrial Use at Secunda.....	49
4.6	Comparison of Options and Recommendations.....	50
4.6.1	Introduction.....	50
4.6.2	Western Basin .....	50
4.6.3	Central Basin .....	51
4.6.4	Eastern Basin .....	52
<b>5.</b>	<b>WESTERN BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE .....</b>	<b>55</b>
5.1	Introduction .....	55
5.2	The Short-Term Intervention.....	55
5.3	The Reference Project.....	55
5.3.1	Abstraction Points .....	55
5.3.2	Critical Levels and Target Operating Levels .....	56
5.3.3	Pumps and Pumping Rates .....	56
5.3.4	Treatment Works .....	57

5.3.5	Residue Management .....	57
5.3.6	Water Users Location and Infrastructure .....	58
5.3.7	Geotechnical Assessment .....	58
5.3.8	Environmental Assessment .....	59
5.3.9	Traffic Impact Assessment .....	59
5.4	Conclusion .....	59
<b>6.</b>	<b>CENTRAL BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE .....</b>	<b>61</b>
6.1	Introduction .....	61
6.2	The Short-Term Intervention .....	61
6.3	The Reference Project .....	61
6.3.1	Abstraction Points .....	61
6.3.2	Critical Levels and Target Operating Levels .....	62
6.3.3	Pumps and Pumping Rates .....	62
6.3.4	Treatment Works .....	63
6.3.5	Residue Management .....	63
6.3.6	Water Users Location and Infrastructure .....	64
6.3.7	Geotechnical Assessment .....	65
6.3.8	Environmental Assessment .....	65
6.3.9	Traffic Impact Assessment .....	65
6.4	Conclusions .....	65
<b>7.</b>	<b>EASTERN BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE .....</b>	<b>67</b>
7.1	Introduction .....	67
7.2	The Short-Term Intervention .....	67
7.3	The Reference Project .....	67
7.3.1	Abstraction Points .....	67
7.3.2	Critical Levels and Target Operating Levels .....	68
7.3.3	Pumps and Pumping Rates .....	68
7.3.4	Treatment Works .....	69
7.3.5	Residue Management .....	69
7.3.6	Water User Locations and Infrastructure .....	70
7.3.7	Geotechnical Assessment .....	70
7.3.8	Environmental Assessment .....	71
7.3.9	Traffic Impact Assessment .....	72
7.4	Conclusions .....	72
<b>8.</b>	<b>THE COSTS AND ECONOMIC ASSESSMENT OF THE LONG-TERM SOLUTION .....</b>	<b>73</b>
8.1	Costs of the Reference Projects .....	73
8.2	Economic Assessment .....	74
8.2.1	Introduction .....	74
8.2.2	Quantitative Expenditure Impacts .....	75
8.2.3	Conclusions .....	76
<b>9.</b>	<b>LEGAL DUE DILIGENCE .....</b>	<b>77</b>
9.1	Introduction .....	77
9.2	Environmental Legislation .....	78
9.2.1	Introduction .....	78
9.2.2	NEMA (107:1998) .....	78
9.2.3	NEM:WA (59:2008) .....	79
9.3	Other Relevant Acts .....	80
9.4	DWA as the Implementing Authority .....	81
9.4.1	Introduction .....	81
9.4.2	Competence of the Department to Undertake the Project .....	82
9.4.3	Site Enablement Issues .....	83
<b>10.</b>	<b>ALTERNATIVE INSTITUTIONAL PROCUREMENT AND FUNDING MODELS .....</b>	<b>85</b>
10.1	Introduction .....	85
10.2	Context .....	85
10.2.1	Registered Project .....	85
10.2.2	Approval to Proceed with Procurement .....	85
10.2.3	Criteria for Procuring an LTS .....	86
10.2.4	The Reference Project .....	87
10.3	Options for Procurement Contracts for the LTS .....	87
10.4	Institutional Options for Managing the LTS .....	88

10.5	Funding Options .....	89
10.5.1	Introduction .....	89
10.5.2	Public Sector Funding .....	89
10.5.3	Private Sector Funding .....	90
10.6	The Procurement Institutional and Funding Models .....	91
10.6.1	Introduction .....	91
10.6.2	Employer Design, Procure, Construct and (the Public Sector Comparator) Operates .....	92
10.6.3	Design, Build/Construct, Operate and Maintain (DBOM): .....	92
10.6.4	Design, Build/Construct, Operate, Maintain and Finance (DBOMF): .....	92
10.7	Financial Control and Reporting .....	93
10.8	Conclusions .....	93
<b>11.</b>	<b>ASSESSMENT OF PROCUREMENT, INSTITUTIONAL AND FUNDING MODELS .....</b>	<b>95</b>
11.1	Introduction .....	95
11.2	Basis for Value Assessment .....	95
11.2.1	Introduction .....	95
11.2.2	Affordability .....	95
11.2.3	Key Assumptions .....	96
11.3	Risk Assessment .....	98
11.3.1	Risks Transfer in the Alternative Models .....	98
11.3.2	Risk Analysis .....	99
11.3.3	Assessment of Value for Money .....	100
11.4	Value for Money .....	104
11.4.1	Comparison of the PSC and DBOM (IA) .....	104
11.4.2	Comparison of DBOM (IA) with DBOMF (PPP) .....	104
11.5	Conclusions .....	105
<b>12.</b>	<b>RECOMMENDATIONS FOR IMPLEMENTATION .....</b>	<b>107</b>
12.1	Introduction .....	107
12.2	The Environment for Planning Implementation .....	107
12.2.1	Water Quantity and Quality .....	107
12.2.2	Costs and Treatment Technologies .....	108
12.2.3	Principles for Implementation .....	109
12.3	Proposals for Implementation in the Western Basin .....	109
12.3.1	Introduction .....	109
12.3.2	Proposals for Implementation for the Medium-Term .....	110
12.3.3	Proposals for Implementation for the Long-Term .....	113
12.4	Proposals for Implementation in the Central Basin .....	114
12.4.1	Introduction .....	114
12.4.2	Proposals for Implementation in the Medium-Term .....	114
12.4.3	Potential Role of Package Plants .....	116
12.4.4	Proposals for Implementation for the Long-Term .....	116
12.5	Proposals for Implementation in the Eastern Basin .....	117
12.5.1	Introduction .....	117
12.5.2	Proposals for Implementation for the Medium-Term .....	117
12.5.3	Potential Role of Package Plants .....	119
12.5.4	Proposals for Implementation for the Long-Term .....	119
12.6	General .....	120
<b>13.</b>	<b>IMPLEMENTATION STRATEGY .....</b>	<b>121</b>
13.1	Cost Recovery .....	121
13.1.1	Cost Recovery from Mines and other Possible Liable Parties .....	121
13.1.2	Cost Recovery Using the Vaal River Tariff .....	123
13.1.3	Cost Recovery through Waste Discharge Charge System .....	123
13.1.4	Environmental Levy .....	124
13.1.5	Conclusions .....	124
13.2	Revenue Collection .....	124
13.3	Procurement Methodology .....	125
13.3.1	Introduction .....	125
13.4	Procurement Process .....	127
13.4.1	Introduction .....	127
13.4.2	Procurement Process .....	127
13.4.3	Procurement Plan for the Western Basin .....	128
13.4.4	Procurement Plan for the Central and Eastern Basins .....	131
13.4.5	Approach to Broad-Based Black Economic Empowerment .....	133

13.4.6	Contract Management .....	133
13.4.7	Development Supervision .....	134
13.5	Risk Management .....	135
13.5.1	Introduction .....	135
13.5.2	Risk Management Plan .....	135
13.5.3	Management of Legal Risks .....	136
13.6	Parallel Implementation Activities .....	137
13.6.1	Environmental Impact Assessment .....	137
13.6.2	Land and Land Rights Options and Access .....	138
13.7	Operation and Maintenance Phase .....	139
13.7.1	Introduction .....	139
13.7.2	Operational and Performance Monitoring .....	140
13.8	Organisational Structure for Implementation .....	142
13.8.1	DWA's Responsibilities and Organisational Requirements .....	145
13.8.2	Proposals for DWA to secure adequate resources .....	147
13.8.3	Summary of Priority Actions .....	147
13.9	Implementation Programme .....	148
13.9.1	Assumptions .....	148
13.9.2	Critical Activities .....	148
13.10	Evaluation of Impacts and Benefits of the Implementation .....	150
13.11	Preparing for Subsequent Implementation .....	151
<b>14.</b>	<b>OTHER REQUIREMENTS FOR SUCCESSFUL MANAGEMENT OF AMD .....</b>	<b>153</b>
14.1	Introduction .....	153
14.2	Hydrological and Hydrogeological Monitoring .....	153
14.2.1	Introduction, Principles and Objectives .....	153
14.2.2	Hydrogeological Monitoring of the Mine Void .....	155
14.2.3	Near-surface Aquifers .....	156
14.2.4	Surface Water .....	157
14.3	Assessing the Dolomitic Stability Risk in the Western Basin .....	158
14.4	Key Stakeholder Engagement and Communication .....	159
14.5	Rehabilitation of Rivers .....	160
14.5.1	Background .....	160
14.5.2	Approach .....	161
14.5.3	Western Basin .....	162
14.5.4	Central and Eastern Basins .....	163
14.5.5	Principles .....	163
14.5.6	Funding .....	163
14.6	Important Supplementary Initiatives .....	163
14.6.1	Reduction of Ingress and Pollution .....	164
14.6.2	Reprocessing of Mine Dumps and Pollution Control .....	165
14.7	Recommendations for a National AMD Strategy .....	165
14.7.1	Changes in Legislation .....	165
14.7.2	Studies .....	165
14.7.3	Trust Funds for Rehabilitation .....	166
14.7.4	Mine Closure Plans .....	166
14.7.5	Creation of a National AMD Trust Fund .....	166
<b>15.</b>	<b>CONCLUSIONS .....</b>	<b>167</b>
	<b>REFERENCES .....</b>	<b>171</b>

## List of Tables

Table 2.1: Possible benefits of ingress control .....	9
Table 2.2: Possible savings as a result of ingress control (annual savings in R million per Ml/d of ingress reduced).....	9
Table 2.3: Summary of anticipated water quality to be abstracted from the void – Western Basin.....	12
Table 2.4: Summary of anticipated water quality to be abstracted from the void – Central Basin .....	13
Table 2.5: Summary of anticipated water quality to be abstracted from the void – Eastern Basin .....	13
Table 2.6: Proposed capacities of the pumps, treatment works and balancing storage .....	16
Table 2.7: Proposed water control levels.....	17
Table 3.1: Summary of standards for various discharges or uses .....	26
Table 3.2: Quantities of sludge to be managed .....	29
Table 3.3: Summary of size and cost estimates .....	30
Table 4.1: Components considered in the Western Basin .....	33
Table 4.2: Components considered in the Central Basin.....	33
Table 4.3: Components considered in the Eastern Basin .....	34
Table 4.4: O&M costs per annum as percentage of capital costs.....	34
Table 4.5: CAPEX and OPEX – Option W1.1.1.1 .....	36
Table 4.6: CAPEX and OPEX – Option W1.1.1.3a.....	37
Table 4.7: CAPEX and OPEX – Option W1.1.1.3b.....	38
Table 4.8: CAPEX and OPEX – Option W2.2.3.1 .....	40
Table 4.9: CAPEX and OPEX – Option C1.1.1.1.....	41
Table 4.10: CAPEX and OPEX – Option C1.1.1.3.....	42
Table 4.11: CAPEX and OPEX – Option C1.1.1.3a.....	43
Table 4.12: CAPEX and OPEX – Option C2.1.1.1.....	44
Table 4.13: CAPEX and OPEX – Option C2.1.1.3.....	45
Table 4.14: CAPEX and OPEX – Option C5.1.1.3a.....	46
Table 4.15: CAPEX and OPEX – Option E1.1.1.1 .....	47
Table 4.16: CAPEX and OPEX – Option E1.1.1.3.....	48
Table 4.17: CAPEX and OPEX – Option E1.1.1.3a.....	49
Table 4.18: Western Basin – Comparison of selected options .....	50
Table 4.19: Central Basin – Comparison of selected options .....	51
Table 4.20: Eastern Basin – Comparison of selected options .....	52
Table 8.1: Reference Project estimated Capital Costs .....	74
Table 8.2: Reference Project estimated Operating and Maintenance costs .....	74
Table 9.1: Legislation relevant to implementation.....	77
Table 10.1: Contracting structures.....	87
Table 11.1: Reference Project's estimated Capital costs .....	97
Table 11.2: Reference Project's estimated Operating and combined lifecycle costs for the LTS and STI.....	97
Table 11.3: Risk-adjusted capital and operating costs (PSC).....	102
Table 11.4: DBOM (IA) operating costs after risk adjustment.....	102
Table 11.5: Economic assumptions or indices.....	103
Table 11.6: DBOMF (PPP) Capital and Operating Costs .....	103
Table 11.7: DBOMF (PPP) Expected Annual Unitary Charge .....	104
Table 11.8: Real Net Present Value for all the options .....	104
Table 11.9: NPV Comparison of PSC and DBOM (IA) .....	104
Table 11.10: NPV Comparison of DBOM (IA) with DBOMF (PPP) .....	105
Table 12.1: Proposed Phasing of Implementation Target date for commissioning .....	120
Table 13.1: Implementation programme - DBOM procurement.....	148
Table 14.1: Possible savings as a result of ingress control (annual savings in R million per Ml/d of ingress reduced).....	164
Table 15.1: Summary of Recommended Actions and Activities .....	168

## List of Figures

Figure 1.1: Study area .....	1
Figure 2.1: Illustration of the ECL, SECL and TOL .....	6
Figure 2.2: Simplified chemical relationships (Holland and Witthüser, 2009) .....	11
Figure 3.1: Disbenefit to the economy of alternative AMD Scenarios for the Vaal River System .....	22



# LIST OF ACRONYMS

AMD	Acid Mine Drainage
ARD	Acid Rock Drainage
B-BBEE	Broad-Based Black Economic Empowerment
BEE	Black Economic Empowerment
BER	Bureau for Economic Research
BOO	Build, Own and Operate
BOOT	Build, Own, Operate and Train
BoQ	Bill of Quantities
BOTT	Build, Operate, Train and Transfer
BRI	Black Reef Incline
CAPEX	Capital Expenditure
CB	Central Basin
CBA	Cost Benefit Analysis
CGS	Council for Geoscience
CM	Crown Mines
CMP	Contract Management Plan
CPI	Consumer Price Index
CRG	Central Rand Gold
CPlan	Conservation Plan
CSIR	Council for Scientific and Industrial Research
DBOM	Design, Build, Operate and Maintain
DBOMF	Design, Build, Operate, Maintain and Finance
DEA	Department of Environment Affairs
DG	Director-General
DMA (57:2002)	Disaster Management Act, 2002 (Act No. 57 of 2002)
DMR	Department of Mineral Resources
DRA (47:1937)	Deeds Registries Act, 1937 (Act No. 47 of 1937)
DRD	Durban Roodepoort Deep
DSRA	Debt Service Reserve Account
DST	Department of Science and Technology
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EB	Eastern Basin
EC	Electrical Conductivity
ECL	Environmental Critical Level
EIA	Environmental Impact Assessment
Eol	Expression of Interest
ERPM	East Rand Proprietary Mines
FS	Feasibility Study
FIDIC	International Federation of Consulting Engineers (French name: Fédération Internationale Des Ingénieurs-Conseils)
GDARD	Gauteng Department of Agricultural and Rural Development
GDP	Gross Domestic Product
GIAMA (19:2007)	Government Immovable Asset Management Act, 2007 (Act No. 19 of 2007)
GN	General Notice
GRCM	Gold Reef City Museum
GRCTF	Gold Reef City Tourist Facility

GWW	Government Water Works
HDPE	High-density Polyethylene
HDS	High Density Sludge
HMC	Hydrological Monitoring Committee
HRA (25:1999)	Heritage Resources Act, 1999 (Act No. 25 of 1999)
HSA (15:1973)	Hazardous Substances Act, 1973 (Act No. 15 of 1973)
IA	Implementing Agent
IGTT	Inter-Governmental Task Team
IMC	Inter-Ministerial Committee
IRP	Integrated Regulatory Process
IS	Immediate Solution
ISP	Internal Strategic Perspective
IWRP	Integrated Water Resource Planning
IX	Ion Exchange
KOSH	Klerksdorp-Orkney-Stilfontein-Hartbeesfontein area
LA	Local Authority
LG	Local Government
LHWP	Lesotho Highlands Water Project
LLRAP	Land and Land Rights Access Process
LLROP	Land and Land Rights Organisational Process
LRA (66:1995)	Labour Relations Act, 1995, (Act No. 66 of 1995)
LSA (8:1997)	Land Survey Act, 1997 (Act No. 8 of 1997)
LTA	Lender's Technical Advisor
LTS	Long-Term Solution
m amsl	meters above mean sea level
mbs	metres below surface
MEC	Member of the Executive Council
MHSA (29:1996)	Mine Health and Safety Act, 1996 (Act No. 29 of 1996)
MoU	Memorandum of Understanding
MPRDA (28:2002)	Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)
MRA	Maintenance Reserve Account
MTEF	Medium-Term Expenditure Framework
NEMA (107:1998)	National Environment Management Act, 1998 (Act No. 107 of 1998)
NEM:WA (59:2008)	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)
NGO	Non-governmental organisation
NPV	Net Present Value
NT	National Treasury
NWA (36:1998)	National Water Act, 1998 (Act No. 36 of 1998)
NWRIB	National Water Resource Infrastructure Branch
O&M	Operation and Maintenance
OPEX	Operating Expenditure
PAJA (3:2000)	Promotion of Administrative Justice Act, 2000 (Act No. 3 of 2000)
PES	Present Ecological State
PFMA (1:1999)	Public Finance Management Act, 1999 (Act No. 1 of 1999)
POA	Procurement Options Analysis
PPP	Public Private Partnership
PSA (103:1994)	Public Service Act, 1994 (Act No. 103 of 1994)
PSC	Public Sector Comparator
PSP	Professional Service Provider
PTP	Pilot Treatment Plants

QA	Quality Assurance
RfC	Ready for Commissioning
RfQ	Request for Qualifications
RfP	Request for Proposals
RfO	Ready for Operation
RL	Rand Leases
RO	Reverse Osmosis
RoD	Robinson Deep
RsD	Rose Deep
RQO	Resource Quality Objective
RU	Rand Uranium
RWQ	Resource Water Quality
RWQO	Resource Water Quality Objective
SAC	Study Administration Committee
SAHRA	South African Heritage Resources Agency
SANS	South African National Standards
SARS	South African Revenue Service
SECL	Socio-Economic Critical Level
SITA	State Information Technology Agency
SITAA (88:1998)	State Information Technology Agency Act, 1998 (Act No. 88 of 1998)
SOE	State Owned Entity
SoW	Scope of Work
SPU	Special Project Unit
SPV	Special Purpose Vehicle
SRK	SRK Consulting (Pty) Ltd
SSC	Study Stakeholder Committee
SSF	Sludge Storage Facility
STI	Short-Term Intervention
SWB	Soil Water Balance
TWP	Thukela Water Project
TWT	Tailings Water Treatment
SWV	South West Vertical
TA 1	Treasury Approval 1
TCTA	Trans-Caledon Tunnel Authority
TDS	Total Dissolved Solids
TOL	Target Operating Level
ToR	Terms of Reference
T&T	Turner & Townsend
TSF	Tailings Storage Facility
TTS	Tailings Treatment System
TWP	Thukela Water Project
TWT	Tailings Water Treatment
URV	Unit Reference Value
VAT Act (89:1991)	Value-Added Tax Act, 1991 (Act No. 89 of 1991)
VMA	Value for Money Assessment
VRT	Vaal River Tariff
WB	Western Basin
WC&WDM	Water Conservation & Water Demand Management
WDC	Waste Discharge Charge
WDCS	Waste Discharge Charge System

WISA	Water Institute of South Africa
WMA	Water Management Area
WQO	Water Quality Objective
WRC	Water Research Commission
WSA (108:1997)	Water Services Act (Act No. 108 of 1997)
WULA	Water Use Licence Application
WWP	West Wits Pit
WWTWs	Waste Water Treatment Works

## ***LIST OF CHEMICAL CONSTITUENTS***

Al	Aluminium
Ca	Calcium
CaCO <sub>3</sub>	Calcium Carbonate
CaSO <sub>4</sub>	Gypsum
Cl	Chloride
Fe	Iron
Fe(OH) <sub>3</sub>	Ferric Hydroxide
Mg	Magnesium
Mn	Manganese
Na	Sodium
SO <sub>4</sub>	Sulphate
U	Uranium

## ***UNITS OF MEASUREMENT***

µg	Microgram
a	Annum
C	Celsius
cm	Centimetre
d	Day
dS	Decisiemens
ha	Hectare
km	Kilometre
km <sup>2</sup>	Square Kilometre
ℓ	Litre
m	Metre
m <sup>3</sup>	Cubic Metre
mg	Milligram
Mℓ	Megalitre
mm	Millimetre
mS	Millisiemens

## GLOSSARY OF TERMS

<b>Adit</b>	An adit is an entrance to an underground mine which is horizontal or nearly horizontal, by which the mine can be entered, drained of water, and ventilated.
<b>AMD</b>	Acid mine drainage is formed when sulphide minerals in the geological strata, are exposed through mining activities and interact with oxygen and water to form a dilute solution of sulphuric acid and iron that leaches other metals from the material in which it forms. Acid mine drainage in the Witwatersrand typically has a pH value around 3 and is enriched in sulphate, iron and a number of metals, often including Uranium.
<b>Appendix</b>	Documents produced by the Feasibility Study attached to the report.
<b>Aquifer</b>	Zone below the surface capable of holding groundwater.
<b>Brownfields</b>	Abandoned or underused industrial and commercial facilities available for re-use.
<b>Central Basin</b>	Central Rand underground mining basin.
<b>Decant (surface)</b>	Spontaneous surface discharge of water from underground mine workings.
<b>Decant (subsurface)</b>	Subsurface flow of water from one mine compartment or geological structure to another, typically occurring when underground mine voids fill and cascade consecutively from one underground compartment to another adjacent connected compartment.
<b>The Department</b>	The Department of Water Affairs (DWA).
<b>Discharge (groundwater)</b>	Seepage of groundwater at the surface.
<b>Eastern Basin</b>	East Rand underground mining basin.
<b>Environmental Critical Level</b>	The level above which the water in the mine voids at the critical locations (that is where the environmental features to be protected are at the lowest elevations) should not be allowed to rise, to protect specific environmental features, including groundwater resources.
<b>Fault</b>	Crack in the earth along which differential movement of the rock mass has occurred.
<b>Feasibility Study</b>	An analysis and evaluation of a proposed project to determine if it is technically sound, socially acceptable, and economically and environmentally sustainable.
<b>Freeboard</b>	The vertical distance below the Socio Economic or Environmental Critical Level at the abstraction point, below which the water level should generally be maintained, to allow for hydraulic gradient across the basin, seasonal peak ingress, pump down time, and the like, i.e. to provide sufficient buffer capacity.
<b>Greenfields</b>	An undeveloped site, especially one being evaluated and considered for commercial development or exploitation.
<b>Groundwater</b>	Water occupying openings below surface

<b>Immediate Solution</b>	The temporary or “Immediate Works” being implemented by TCTA in the Western Basin to stop decant, to neutralise the AMD and to remove metals from the AMD.
<b>The Implementer</b>	The term “Implementer” is used to include the alternatives of implementation by DWA, together with a PSP support team and Contract Management team in the form of a Public Entity, or implementation by a Public Entity who are appointed as the Implementing Agent (IA).
<b>Key stakeholder</b>	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 Government, NGOs, organised business, mining, industry, labour, agriculture, affected mines, affected water utilities, community leaders, academics, etc.).
<b>Layout</b>	The arrangement or configuration (site layout, pipe route, etc.) of a specific option.
<b>Long-Term Solution</b>	A solution that is sustainable in the long term with regards to the technical, ecological, legal, economic, financial and institutional aspects.
<b>Mine plan</b>	Accurate drawing showing the positions of mine excavations.
<b>Option</b>	One of a number of combinations of abstraction works, treatment processes, and solutions for the disposal of waste and utilisation of treated water.
<b>Preferred option</b>	The solution, or combination of solutions, for the three basins respectively and collectively, that will be selected for further investigation in the feasibility phase, and if found feasible, that would eventually be recommended for implementation.
<b>Ramsar Convention</b>	The Convention on Wetlands of International Importance, especially as Waterfowl Habitat - An international treaty for the conservation and sustainable utilization of wetlands, i.e., to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. It is named after the town of Ramsar in Iran.
<b>Ready for Operation</b>	The milestone, after commissioning when a project is fully functional and can be put into service.
<b>Reef</b>	Term used in the Witwatersrand mines for conglomerate containing gold deposits.
<b>Reference Project</b>	The option, which uses proven technologies, has minimum risk and which, is used for financial modelling and budgeting. It will probably not be the option which is implemented but is the benchmark against which implementation proposals will be judged.
<b>Reserve</b>	The quantity and quality of water required to satisfy basic human needs and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.
<b>Resource Quality Objectives</b>	Resource Quality Objectives (RQOs) capture the Management Class of the Classification System and the ecological needs determined in the Reserve into measurable management goals that give direction to resource managers as to how the resource needs to be managed. RQOs may relate to, the Reserve, the

	instream flow, the water level, the presence and concentration of particular substances in the water, the characteristics and quality of the water resource and the instream and riparian habitat, the characteristics and distribution of aquatic biota, the regulation or prohibition of instream or land-based activities which may affect the quantity of water in, or quality of the water resource; and any other characteristic, of the water resource in question.
<b>Resource Water Quality Objectives</b>	A numeric or descriptive instream (or in-aquifer) water quality objective, typically set at a finer resolution (spatial or temporal) than Resource Quality Objectives to provide greater detail upon which to base the management of water quality (Resource Directed Management of Water Quality, 2007).
<b>Request for Information</b>	A Request for Service Providers to provide information (RfI) on their product or service, e.g. technologies. It is not part of a procurement process.
<b>Request for Qualifications</b>	A Request for Qualifications (RfQ) from Service Providers to allow a shortlist to be prepared. It is normally the first step in the procurement process.
<b>Request for Proposals</b>	A request for technical and financial proposals (RfP) in compliance with a defined Scope of Work (SoW) and adjudication criteria from (pre-qualified) bidders to allow one of the bidders to be appointed to provide an agreed service. Equivalent to Expression of Interest (EoI) but used in infrastructure projects
<b>Scenarios</b>	An alternative projection of the macro environment which affects AMD, such as climate change, electricity load shedding, and changes in quality or quantity of water ingress to the mine void.
<b>Service Provider</b>	The generic term for the Special Purposes Vehicle (SPV) or contracting consortium that will design, build, operate and maintain and possibly finance the works.
<b>Short-Term Interventions</b> (Short-Term Solution as stated in Terms of Reference)	Emergency measures that are being implemented by TCTA in the short-term in all three the basins while the long-term Feasibility Study is undertaken to protect the ECL, to neutralise the AMD and to remove metals from the AMD.
<b>Socio-Economic Critical Level</b>	The level above which the water at the critical location in the mine void must not be allowed to rise, to protect specific social or economic features, such as the Gold Reef City museum and active or planned mining.
<b>Target Operating Level</b>	The level in the mine void at each abstraction point, at which the water level should generally be maintained by pumping or gravity flow to allow for hydraulic gradient across the underground mining basin, seasonal peak ingress, pump down time, and the like, i.e. to provide sufficient buffer capacity or freeboard required below the ECL or SECL across the basin.
<b>Water table</b>	The level in an aquifer below which the said aquifer are filled with water.
<b>Western Basin</b>	West Rand underground mining basin.





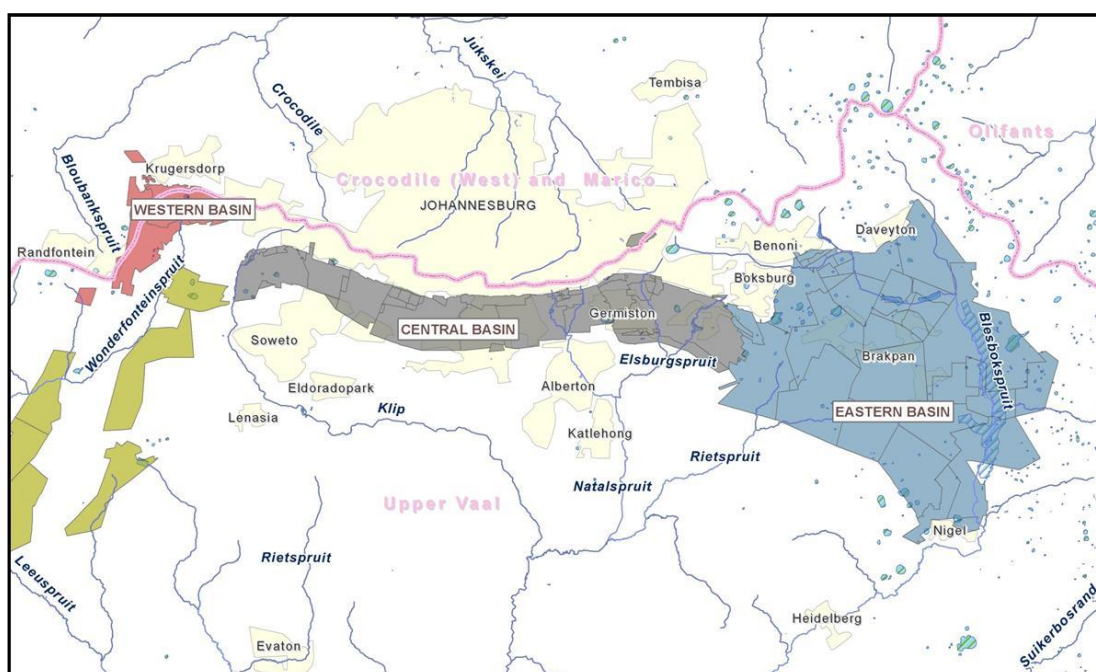
# 1. INTRODUCTION

## 1.1 Background

The Preface provides the background to the challenge of Acid Mine Drainage (AMD) in the Witwatersrand and describes the scope of the Study, as well as the approach followed to recommend the Long-Term Solution (LTS) for managing the AMD associated with the Western, Central and Eastern underground mining basins (Western, Central and Eastern Basins). It also summarises the current Short-Term Interventions (STI) to control AMD, which are discussed in more detail in the report.

The Study took cognisance of various strategies prepared by the Department of Water Affairs - “The Department” (DWA), including the **“National Water Resource Strategy”** (DWA, 2013), strategies for the **“Vaal River System: Large Bulk Water Supply Reconciliation Strategy”** (DWA, 2009), the **“Crocodile (West) River System: Large Bulk Water Supply Reconciliation Strategy”** (DWA, 2009), the **“National Strategy for Water Re-use”** (DWA, 2013) and the **“National Desalination Strategy”** (DWA, 2013).

The Study Area is shown in **Figure 1.1**.



Source: Council for Geoscience (CGS). 2010. Mine Lease Areas in the Western, Far-Western, Eastern, Central and KOSH Basins. Shape File. Developed for the Department of Mineral Resources (DMR), Johannesburg, South Africa

**Figure 1.1: Study area**

The AMD situation in July 2013 was as follows.

- In the Western Basin, the first phase of the Immediate Works had been implemented, and decant was stopped in mid-2012. Only neutralised water was being discharged into the Tweelopies Spruit, resulting in some improvements in the condition. The pumps envisaged in the STI are expected to be commissioned during 2013.
- In the Central Basin, the STI's High Density Sludge (HDS) neutralisation plant is under construction and due to be commissioned in early 2014. It will discharge neutralised water into the Klipspruit.
- In the Eastern Basin, the tender for the STI works, pumps for abstraction, an HDS plant and ancillary works has been advertised, and commissioning of the works is scheduled for December 2014. The neutralised water from the HDS plant will be discharged into the Blesbokspruit.

As described in the Preface, the discharge of neutralised but saline water into the Crocodile (West) and Vaal River Systems is not sustainable, and the LTS should be implemented as soon as possible. The LTS comprises the implementation of treatment plants and ancillary works to desalinate the neutralised water, supply the water to suitable users and manage the residues from the treatment. In parallel, a number of other important activities to complete the recommendations of this Study for the long-term management of AMD in the Witwatersrand should be executed.

## 1.2 This Report

This DWA AMD FS 2013, Study Report No. 10: **“Feasibility Report”** summarises the main findings of all the reports for this Study, as listed in the Document Index on page i, and concludes by making some recommendations for inclusion in a National Strategy for managing AMD, which is being prepared by the Department.

The purpose of the LTS is to ensure long-term security of water supply and continual fitness for use of water in the Vaal and Crocodile (West) River Systems through managing the AMD from the three Witwatersrand mining basins.

The technical process for identifying the preferred LTS involved a cascading approach, including literature reviews, desk studies, detailed investigations, stakeholder engagement and site visits. The cascading process has been captured in the following reports:

- DWA AMD FS 2013, Study Report No. 5: **“Technical Prefeasibility Report”** on the Long-Term Solution; this report summarises the Prefeasibility Phase, which considers several options for the LTS and recommends Reference Projects by drawing on and summarising the following reports:
  - DWA AMD FS 2013, Study Report No. 5.1: **“Current Status of the Technical Management of Underground AMD”**, which looks into current practices and in particular the STI that are being implemented;

- DWA AMD FS 2013, Study Report No. 5.2: **“Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids”**, which assesses the present and likely future quantity and quality of the mine void water to be treated and the connectivity of the pumping shafts;
- DWA AMD FS 2013, Study Report No. 5.3: **“Options for Use or Discharge of Water”**, which addresses the possible beneficial uses of treated water and aids in identifying end-users;
- DWA AMD FS 2013, Study Report No. 5.4: **“Treatment Technology Options”**, which identifies alternative technologies that can treat AMD to acceptable standards and selects the reference process for implementation; and
- DWA AMD FS 2013, Study Report No. 5.5: **“Options for the Sustainable Management and Use of Residue Products from the Treatment of AMD”**, which identifies methods for dealing with residue from the treatment process.

The elaboration of the Reference Projects is set out in the following reports:

- Confidential Study Report No. 6 **“Concept Design”**, which provides the process flow diagrams and the assumptions for the concept design and defines the Reference Projects. It also discusses some of the alternatives for consumptive water use;
- Confidential Study Report No. 6.1 **“Concept Design: Drawings”**, which provides the site layouts and potential pipeline routes for the Reference Projects; and
- Confidential Study Report No. 6.2 **“Concept Design: Costing”**, which provides the estimated capital and lifecycle costs. These confidential reports will be released once the procurement process reaches an appropriate stage.

Chapter 2 describes the problem and the need for action, as set out in the Study Report No. 5.2. Chapter 3 discusses the assessment of options, which are described in detail in Study Reports Nos. 5.3, 5.4, and 5.5.

Chapter 4 describes the compilation of complete solutions for managing the AMD before describing the recommended solution for each basin, as described in the Study Report No. 5.

Chapters 5, 6 and 7 summarise the technical development (planning, impact assessments and costing) of the solution proposed for each basin. These are termed the Reference Projects, which will be used to guide the procurement and other implementation activities, and serve as the benchmark against which proposals received in response to the Request for Proposals (RfP) or tender enquiry will be judged. The details are given in the Confidential Study Report Nos. 6, 6.1 and 6.2. These chapters also describe the due diligence to which the Reference Projects were subjected, which is described in Confidential Study Report No. 7 **“Institutional, Procurement and Financing Options”**.

That report also describes the Economic Assessment of the LTS, which is set out in Chapter 8 (together with the costs of the Reference Projects), and the Legal Due Diligence, which, is summarised in Chapter 9 once the Concept Designs were confirmed.

The alternative models for procurement, as well as possible institutional and funding arrangements associated with the Reference Project, were considered, as described in Chapter 10. The value assessment, which is also presented in the Confidential Study Report No. 7, is discussed in Chapter 11.

Chapter 12 defines the principles and approach that guided the planning of the LTS and describes the proposals for implementation which are set out in the DWA AMD FS 2013, Study Report No. 8: **“Implementation Strategy and Action Plan”**.

Chapter 13 describes the strategy for implementing the works required for the LTS, and summarises the proposals for funding and cost recovery, the activities and programme for implementation, the proposed organisational arrangement and other requirements to complete implementation. The Chapter is a summary of the report on the Implementation Strategy (Study Report No. 8).

The other important activities during implementation are risk management, communication and the implementation of a comprehensive monitoring programme. These are described in Chapter 14, based on Study Report No. 8. There are a number of other requirements for the successful long-term management of AMD, including controlling ingress and the rehabilitation of rivers, some of which are being implemented by Government Departments other than the Department, are also discussed in Chapters 16, based on work which is reported in Study Report No. 8.

This report concludes, in Chapter 15, with the recommendations for the National Strategy for managing AMD, based on the understanding of the problem and lessons learnt in completing this Study.

## **2. NEEDS ASSESSMENT**

### **2.1 Hydrogeological Assessment**

#### **2.1.1 Introduction**

This chapter is based on Study Report No. 5.2, which assesses the geology, hydrogeology and hydrochemistry of the Western, Central and Eastern Basins to provide the background information necessary for planning how to manage the rising AMD in order to protect the environment and socio-economic assets in all three basins.

That report also compares the findings of this Study and the results of the studies for the STI with respect to critical water levels, abstraction points, ingress rates and water qualities, and assesses how either the STI can be influenced by the LTS or how the STI can be effectively incorporated into the LTS.

In the Western and Eastern Basins, the LTS could influence the planning of the STI. In the Central Basin, however, the location of the abstraction and neutralisation plants for the STI contract was already fixed and any changes would have delayed implementation, probably leading to breaching of the Environmental Critical Level (ECL) and unacceptable environmental risks.

This Study has reached somewhat different conclusions on the critical water levels, predicted water quality and required pumping rates from the understandably conservative findings of the STI study. If this Study's conclusions are correct, the adjustments that will inevitably be required during operation of the STI can easily be accommodated.

However, the STI proposals are considered acceptable to meet the requirements as stipulated in the directives that were issued by the Department of Water Affairs to the Trans-Caledon Tunnel Authority (TCTA).

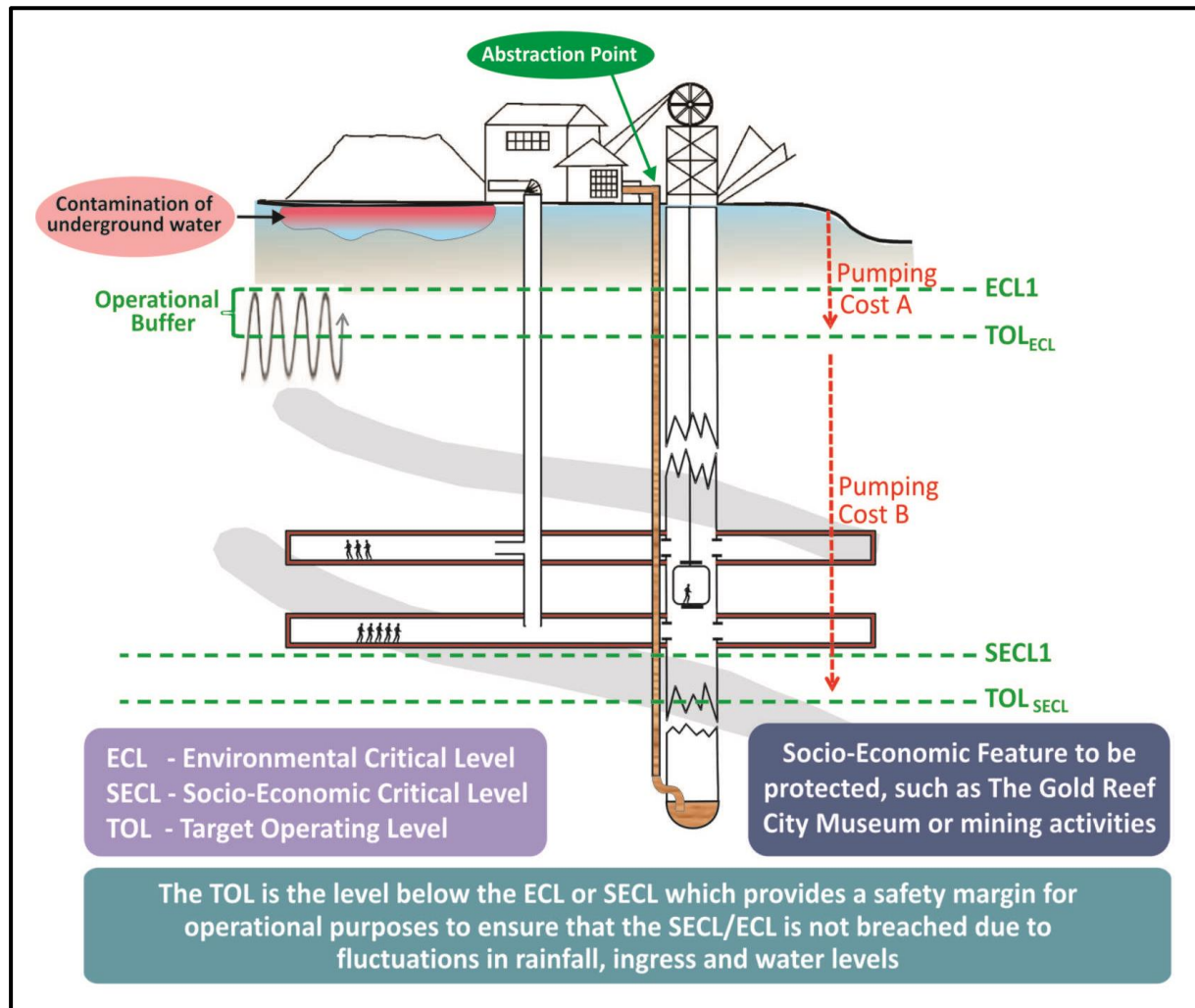
#### **2.1.2 Critical Water Levels**

A key objective of that report was to define critical water levels in each of the basins and estimate the time at which the water in each basin will reach these levels. The critical water levels under consideration are:

- The ECL, being the level above which the water in the mine voids should not be allowed to rise at the critical location (that is, where the environmental features to be protected are at the lowest elevations) in order to protect certain environmental features, including groundwater resources. The Socio-Economic Critical Level (SECL), being the level above which the water at the critical location in the mine void must not be allowed to rise in order to protect certain social or economic features, such as the underground mine museum at the Gold Reef City Tourist Facility (GRCTF) and active or planned mining. In all three basins, the potential remains for new mining operations to become economically

feasible, especially with increasing gold prices, in which case appropriate SECLs would have to be set.

- The Target Operating Level (TOL), being the level in the mine void at each abstraction point at which the water surface should generally be maintained by pumping, or gravity flow below the ECL or SECL, in order to allow sufficient freeboard or buffer capacity for the hydraulic gradient across the basin, seasonal peak ingress and pump down time. (The freeboard is the vertical distance below the ECL or SECL at the abstraction point to the TOL). The ECL, SECL and TOL are illustrated in **Figure 2.1**.



**Figure 2.1: Illustration of the ECL, SECL and TOL**

#### a. Western Basin

In the Western Basin where the mine void water is at or very close to the surface at Black Reef Incline (BRI), the objective is to eliminate or reduce the risks of polluting the springs feeding the Tweelopies Spruit and of polluting the sub-surface flow to the Zwartkrans Compartment dolomitic aquifer that hosts the Cradle of Humankind. It is anticipated that this will be achieved if the mine void water is prevented from entering the dolomitic aquifer via the Black Reef Mine workings at approximately 1 610 m amsl. Therefore, a critical ECL-1 of 1 600 m amsl is proposed. In the long term, it is anticipated that a freeboard (or 'buffer') of



15 m should be adequate, and a TOL of 1 585 m amsl is recommended. The water should be held at that level for an appropriate duration (probably 6 to 9 months) to allow the water level in the entire void to drain down to that level. It is generally accepted that pollution of the downstream dolomitic aquifers when the AMD was decanting was caused by ingress from the polluted Tweelopies Spruit. On-going monitoring should be used to establish whether (with the water in the void below 1 600 m amsl), the water in the Tweelopies Spruit and downstream aquifers is free of pollution from AMD. If pollution by AMD has ceased and if the ECL has not been breached with a TOL of 1 585 m amsl, which level should be maintained (i.e. the water should be held at this level).

If the situation is not satisfactory, the level should be lowered further until the desired result is obtained. It is expected that with an ECL-2 of 1 565 m amsl, which should be below the base of the dolomitic outlier, all pollution will almost certainly have ceased. In this case, the long-term TOL is recommended to be at 1 550 m amsl, which is the same as the ECL proposed for the STI. Lowering the TOL by 35 m will cost approximately R1.2 million/a to pump 23 Mℓ/day, which is predicted to be the volume to be pumped, at least initially, to maintain the TOL. No SECL is currently envisaged for the Western Basin.

#### **b. Central Basin**

For the Central Basin, the ECL is intended to protect the shallow weathered aquifers and the groundwater regime feeding springs and base flow in streams. The most vulnerable areas are around the anticipated decant points of East Rand Proprietary Mines (ERPM), Cinderella East and Cinderella West Shafts, which are at about 1 620 m amsl. Maintaining the water level in the void at a depth of 100 m below surface in this area (i.e. at an ECL of 1 520 m amsl) is proposed. A programme of drilling and water quality testing in the lower-lying aquifers, where any contamination is most likely to be first detectable, is recommended in order to improve the definition of the depths of the shallow aquifer and provide baseline water quality data, which will enable a more accurate elevation to be determined for the ECL. It may then be necessary to limit the depth to which abstraction boreholes are sunk in aquifers where AMD pollution is detected and which cannot economically be protected by lowering the ECL.

In the long term, a freeboard of 20 m is expected to be adequate to protect the ECL. The recommended TOL ECL is thus 1 500 m amsl. However, due to the size of the basin (55 km across), there are a number of unknowns, including how the water levels in the mine void will vary, both spatially and temporally, so a greater initial freeboard is recommended. Given that, by the time the STI is commissioned, the water level in the void is expected to be at about 1 495 m amsl (i.e. a freeboard of 25 m); the water level should then be lowered to 1 470 m amsl to give an initial freeboard of 50 m below ECL of 1 520 m amsl). This is similar to the ECL (including a 'buffer') of 1 467 m amsl, as proposed for the STI. The freeboard and thus the TOL should be adjusted in future, based on the monitoring of the water levels in the void across the basin.

The underground museum at the GRCTF on 5 Level (1 484 m amsl) in Crown Mines No. 14 Shaft was taken to be the critical factor in determining the SECL-1. The SECL-1 is set at an elevation of 1 474 m amsl to accommodate the lowering of the double-decker conveyance and to ensure that the museum can continue to be visited as a heritage site. If the SECL-1 is used, then the TOL SECL must ensure that there is sufficient freeboard to allow for potential slow flow rates between the Gold Reef City Museum (GRCM) and the pump site. A long-term TOL SECL of 1 454 m amsl is proposed if the SECL is to be protected, but the behaviour of the water level in the void at this shaft should be monitored to verify this. Currently, the GRCTF is planning to vacate the museum on 5 Level before the water level reaches it, in about November 2013. They may relocate the museum to 2 Level (1 624 m amsl) or refurbish 5 Level and re-established the museum, once the water has been lowered sufficiently. It will cost approximately R 3 million per annum to maintain the TOL at 1 454 and not 1 500 m amsl.

An alternative SECL-2 of 1 246 m amsl, about 400 m below surface at South West Vertical (SWV) Shaft, is being considered to allow mining to that depth. If this takes place, the TOL to protect either SECL-1 or the ECL will have to be set before mining operations close down and the water is allowed to rise. Whatever levels are set, monitoring of the near-surface aquifers of the basin is very important.

### c. Eastern Basin

In the Eastern Basin, an ECL-1 of 1 470 m amsl, about 100 m below surface and thus below the water table, which is at the surface in the dolomitic aquifer, is expected to be low enough to protect the aquifer from pollution. A long-term freeboard of 20 m is proposed, giving a TOL-1 of 1 450 m amsl. However, it is recommended that, initially, an ECL of 1 280 m amsl at the base of the dolomite would be desirable. This ECL, 190 m lower than the proposed long-term ECL, is considered to be very conservative, and no freeboard or buffer is proposed, so the associated TOL would also be 1 280 m amsl. The conservative ECL in the Eastern Basin (1 280 m amsl) is estimated to be reached by mid-2014, but the STI will probably only be commissioned in December 2014. It is recommended that, if adequate monitoring of the dolomitic aquifer is in place, the water level be held at the level at the time of the STI is Ready for Operation (RfO), provided that it is below TOL-1 of 1 450 m amsl (i.e. that the level is adopted as the initial TOL).

If adequate monitoring of the water quality in the dolomite has been established, and no pollution of it is observed at that TOL, the water level can be allowed to rise, in say 10-metre steps every three months, possibly as high as TOL-1 at 1 450 m amsl, provided that the recommended monitoring is carried out and no AMD pollution is detected. No SECL is currently set for the Eastern Basin.



### 2.1.3 Surface Water Ingress

The impact of surface water ingress directly into the underground workings is significant for all three basins. The ingress occurs mainly via reef outcrops, opencast mine pits and backfilled workings, tailings dams, as well as from rivers and other water bodies and potentially from leaking water and waste water distribution systems. Much of the ingress cannot easily be controlled as there are many diffuse sources within the basins, but the rehabilitation of open pits and sealing of other direct inflow paths need to be implemented as soon as possible to minimise water entering the mine voids.

The estimated volume of water entering the mine void in each basin, and the volume that could be prevented through ingress control, are shown in **Table 2.1**.

**Table 2.1: Possible benefits of ingress control**

Basin	Predicted ingress (Mℓ/d) with no ingress control		Predicted saving (Mℓ/d)	Predicted ingress (Mℓ/d) with improved ingress control	
	Average	Range		Average	Range
Western	23	19–27	5	18	14–22
Central	46	30–90	10	36	24–74
Eastern	80	70–100	21	59	49–79

Source: DWA AMD FS 2013, Study Report No. 5 “*Technical Prefeasibility Report*”

This possible reduction in ingress has been ignored in the sizing of infrastructure and in estimating long-term operating costs. However, the estimated saving in operating costs that can be achieved, by reducing the volumes of water that must be pumped and treated, are shown in **Table 2.2**.

**Table 2.2: Possible savings as a result of ingress control (annual savings in R million per Mℓ/d of ingress reduced)**

Basin	Annual Savings							
	Pumping (R mil per Mℓ/d)	Treatment (R mil per Mℓ/d)		Sludge disposal (R mil per Mℓ/d)	Treated water delivery (R mil per Mℓ/d)	Combined saving (R mil per Mℓ/d)	Assumed ingress reduction (Mℓ/d)	Total annual saving (R mil)
		HDS	RO					
Western	0.22	1.45	3.00	1.27	0.12	6.1	5	30.5
Central	0.24	1.39	3.35	0.83	0.20	6.0	10	60.0
Eastern	0.29	0.88	1.59	0.63	0.20	3.6	21	75.6
Total possible saving with assumed ingress control (R million/a)								166.1

Source: DWA AMD FS 2013, Study Report No. 5 “*Technical Prefeasibility Report*”

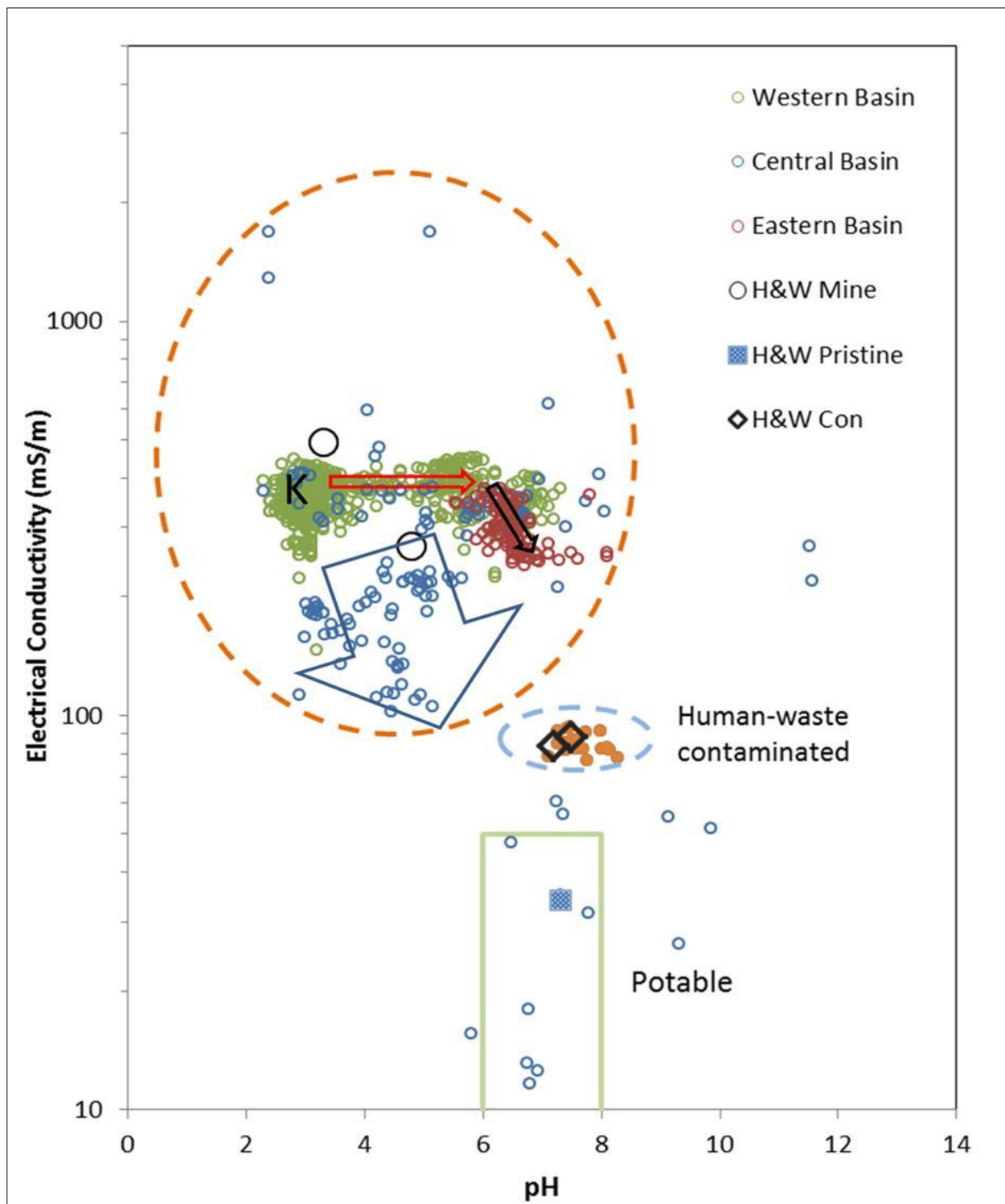
The Department of Mineral Resources (DMR), through the Council for Geoscience (CGS), have carried out feasibility studies and designed some river canalisation as control measures in the Central Basin. These should be implemented as soon as possible, and further studies should be carried out as a matter of urgency, to establish both the practicality and cost-effectiveness of controlling ingress in the Western and Eastern Basins and from various other sources. In the long term, this could potentially reduce the required pumping rates and hence, the pumping, treatment and maintenance costs.

This possible reduction in ingress has been ignored in the sizing of infrastructure and in estimating long-term operating costs, but should be considered in the detailed planning, including the distribution of treated water.

#### **2.1.4 Water Quality**

In the Study Report No. 5.2, the possible future AMD chemistry was estimated for the three basins, based on data from the most appropriate data sets and samples.

The data cluster marked “K” in **Figure 2.2** is regarded as the best estimate of primary AMD. These samples have pH values of between 2 and 4, and Total Dissolved Solids (TDS) values of approximately 3 850 mg/l, varying by 1 000 mg/l on either side. The combination of salts shows relatively little variation in composition. The weight ratios of SO<sub>4</sub>:Ca:Mg:Na:Fe:Al = 65:15:5:5:1:0.5 (ranges: 60-75:10-25:4-7:4-10:0.1-6:0-3), as determined for the Central Basin, on average seem to hold well for the other basins as well.



**Figure 2.2: Simplified chemical relationships (Holland and Witthüser, 2009)**

Lower salt concentrations are reported in Study Report No. 5.2 than by TCTA, because of the data sets used.

Electrical Conductivity (EC) in the Western Basin AMD is measured at about 350 mS/m, which represents about 3 850 mg/l of TDS, with recorded pH values between 2 and 7, depending on the degree of neutralisation, probably through interaction with dolomitic water.

The Central Basin data are scattered over a wide field, reflecting the diversity of samples in the database, ranging from extremely contaminated surface samples (EC ~1 050 mS/m) to water in the potable range. A large number of samples plot at EC ~100 to 200 mS/m and pH between 2 and 6. The latter samples originate largely from the Durban Roodepoort Deep (DRD) Circular and Crown Mines (CM) 3 Vent Shafts, and represent the dilution effect of better-quality surface ingress on the AMD in the mine void.

The Eastern Basin samples cluster at an EC of about 300 mS/m (TDS ~3 300 mg/l) and pH between 5 and 8. These samples show a trend (black arrow in **Figure 2.2**) of improvement of the water quality during pumping. This improvement is probably the combined result of dilution and neutralisation by dolomite-equilibrated water.

The uncertainties inherent in the data, and in particular in the understanding of the void characteristics and behaviour, do not allow for predictions to be made with high accuracy. These uncertainties will best be managed by adopting an initially conservative approach and by a well-planned water quality monitoring programme that is implemented as soon as pumping commences as part of the STI. Variability in the water quality during the initial stages of pumping should be expected. This variability should reduce after some months when the water in the voids approaches hydraulic equilibrium.

The anticipated water qualities are summarised in **Tables 2.3, 2.4 and 2.5**.

**Table 2.3: Summary of anticipated water quality to be abstracted from the void – Western Basin.**

Parameter	Unit	Percentile			
		5th	50th	75th	95th
pH	@ 25°C	6.5	3.2	3.0*	2.7
EC	mS/m@ 25°C	291	363	390	426
TDS <sup>^</sup>	mg/l	3 381	4 313	4 748	5 388
Total alkalinity	mg/l CaCO <sub>3</sub>	21	719	965	1 255
Mg	mg/l	-	-	-	-
Ca	mg/l	419	544	597	823
Na	mg/l	65	101	125	243
Cl	mg/l	-	-	-	-
Fe	mg/l	1	185	463	799
Al	mg/l	-	-	-	-
Mn	mg/l	11	56	70	114
SO <sub>4</sub>	mg/l	2 140	2 730	3 005	3 410
U	µg/l	-	-	-	100
<sup>^</sup> Estimated * Linearly interpolated Number of samples = 651 for all parameters Data accumulated between January 2011 and March 2012					

**Table 2.4: Summary of anticipated water quality to be abstracted from the void – Central Basin**

Parameter	Unit	Percentile			
		5 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	95 <sup>th</sup>
pH <sup>#</sup>	@ 25°C	4.4	3.0	2.8	2.4
EC	mS/m	371	397	412	465
TDS <sup>^</sup>	mg/l	4 078	4 363	4 429	5 118
Total alkalinity	mg/l CaCO <sub>3</sub>	2.5	2.5	8.9	34
Na	mg/l	108	122	169	171
Mg	mg/l	118	172	201	258
Al	mg/l	10	122	133	193
Ca	mg/l	241	279	403	563
Fe	mg/l	1	40	48	108
Mn	mg/l	13	47	49	50
Cl	mg/l	84	137	141	146
SO <sub>4</sub>	mg/l	2 429	2 831	2 953	3 062
U	µg/l	56	606	657	695
<sup>^</sup> Estimated Number of samples = 12 for all parameters					

**Table 2.5: Summary of anticipated water quality to be abstracted from the void – Eastern Basin**

Parameter	Unit	Percentiles			
		5 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	95 <sup>th</sup>
pH	@ 25°C	7.1	6.5	6.3*	5.9
EC	mS/m	98	280	314	363
TDS <sup>^</sup>	mg/l	484	2 292	2 840	3 358
Total alkalinity	mg/l CaCO <sub>3</sub>	12	168	232	560
Na	mg/l	58	208	238	264
Mg	mg/l	0	54	119	166
Al	mg/l	0	0	0	2
Ca	mg/l	0	77	379	421
Fe	mg/l	0	74	126	227
Mn	mg/l	0	3	4	6
Cl	mg/l	66	157	184	254
SO <sub>4</sub>	mg/l	240	1 148	1 610	2 289
U	µg/l	1	10	92	470
<sup>^</sup> TDS as received from the source <sup>*</sup> Linearly interpolated					

### 2.1.5 Selection of Locations for Abstraction

The success of the abstraction method chosen depends on its ability to lower the void water level to ensure that decant and pollution of groundwater does not occur, and abstract the best quality water possible. A desk-top review of possible abstraction points (locations with access to the mine void) was undertaken, which involved the review of mine plans and personal interviews where required, complemented with video logging of some shafts by Mine Rescue Services on behalf of the Trans-Caledon Tunnel Authority (TCTA).

It is considered preferable to abstract from shafts or inclines that are well connected with the mine void at shallow levels to maximise the recycling of shallow ingress, leaving the deep, highly contaminated water undisturbed. Turnover of the shallow ingress water will lead to more rapid flushing of the shallow system. Abstracting from a shaft incline or boreholes that are connected to the mine void close to surface on multiple levels also ensures connectivity, even if there is a collapse on one level.

For the Western Basin, Rand Uranium (RU) No. 8 Shaft meets all the criteria and is currently used to pump AMD water, using two submersible pumps with a capacity of 8 Ml/d each. The connectivity of RU No. 8 Shaft with the mine void has been proven and it should be suitable for the LTS. However, the stability of the shaft should first be checked and it should be inspected regularly to check its stability. The RU Shaft No. 9 is nearby and being used by Mintails. It could be considered as an alternative if necessary. The option of abstracting from No. 8 Shaft, through a gravity tunnel, was investigated and is discussed in Chapter 4.

For the Central Basin, the SWV Shaft at ERPM was identified in the TCTA (2011) Study as the site where the pumps will be installed, and tenders had already been invited for pump installation and treatment works at this site when this Study was starting. A major disadvantage of this shaft is that the shallowest connection to the mine void is very deep on 24 Level, 1 080 metres below surface (mbs) via a single haulage, which will have to carry most of the discharge. However, the AMD from all the other compartments will decant from West to East through connections at relatively shallow depths before decanting into the ERPM compartment at about 575 mbs. Thus, due to compartmentalisation of the Central Basin, it is likely that only relatively shallow water will be drawn towards ERPM from the west, and the deep mine water in the west and central parts of the basin will remain undisturbed. The SWV Shaft is connected at 30 Level to another shaft (South West Sub-Vertical Shaft), which is well connected to the void at depth. If there is a collapse in the haulage on 24 Level, water will be drawn into the shaft from considerable depth via the sub-vertical shaft. Flow might also be restricted because of reports that the lower portion of the SWV Shaft was damaged in the mid-1990s and not repaired, which may have affected the connectivity of the two shafts. However, this Study considers the SWV Shaft to be suitable for at least the medium term (10 to 15 years), but recommends further investigations for the long term.

The option of abstraction by a tunnel was considered, but would still require some pumping and was not economic (Study Report No. 5).

There is a ventilation shaft close to SWV Shaft (500 m to the north-west) that could serve as back-up pumping location in the event of problems with SWV and could relatively easily be connected directly to the HDS plant. This shaft was considered in the STI investigations, but was rejected because it was too small for multiple pumps (it has a 6 m diameter) and is connected to the void by a single tunnel. It is recommended that this ventilation shaft be located and protected for possible use in the future.

A preferable longer term approach would be to abstract at SWV and up to four or more other locations with greater connectivity with the void at a shallow level. Most of the still accessible vertical shafts on the Central Rand intersect the void at considerable depth because most of the shallower reefs were accessed by incline shafts, such as the Cason Shaft. The incline shafts have the advantage of being connected directly to the mine void at shallower depths, on multiple levels, and being easily accessible even without headgear.

However, preparing and equipping an incline shaft would require considerable lead times and may not be practical for large submersible pumps. The upper portions of these shafts are located on the reef layer, and as a result are not regular but may roll with the reef. There is also some risk regarding shaft stability when considering incline shafts over vertical shafts. A detailed investigation of potential vertical and incline shafts that may have greater interconnectivity would require a detailed study of multiple criteria, which was beyond the scope of this Study.

Access and infrastructural constraints may necessitate the consideration of an alternative strategy of large-diameter boreholes drilled into the mine void for pump installation. The holes should be drilled to intersect carefully selected locations in the mine void, with good connectivity at shallow and other depths. This alternative strategy will reduce the risk from the failure of a pump shaft due to collapse of the shaft itself or underground tunnels. In addition, pumping from shallower levels is likely to result in more rapid improvement in the pumped water quality. Pipelines would have to be installed to convey water to one or more suitably located treatment plants. This option should be investigated in the same study as the assessment of shafts. These investigations should be undertaken as soon as possible so that there is an alternative plan if problems are encountered.

In the Eastern Basin, TCTA identified Grootvlei No. 3 Shaft as a possible pumping shaft, as it has been utilised in the past and proved to be sufficiently connected. Examination of the mine plans confirmed that it is well connected to the Kimberley Reef and, because of a plug in the shaft above the connection to the deeper Nigel Reef, only indirectly connected to that reef. Water pumped from the shaft cannot be drawn directly from the Nigel Reef and will mainly be water from the shallower Kimberley Reef. However, due to its proximity to the dolomites in the area, lack of space for the required infrastructure, and in order to see if the pumping head could be reduced, several alternatives were considered. Based on an inventory of shafts in the Eastern Basin prepared by Gold One and camera surveys by Mine Rescue Services, Marievale No. 5 Shaft was identified as a suitable alternative. This shaft is located at a 20 m lower elevation, south of the dolomite and wetlands, avoiding the return of water releases to the void. It has direct connectivity, via haulages, to both the Nigel (Main) Reef and Kimberley Reef. There is also adequate space for pumping infrastructure.

On balance, due to the fact that Grootvlei No. 3 Shaft draws directly from the shallower Kimberley Reef void and only indirectly from the deeper Nigel Reef void (due to the plug), and that successful pumping was carried out at Grootvlei No. 3 Shaft in the past, this shaft is considered marginally superior to Marievale No. 5 Shaft for abstraction, provided that the

surface concerns can be managed. However, Marievale No. 5 Shaft could be a suitable alternative should the need arise. Abstraction via a tunnel is not an option in the Eastern Basin due to the low level of the TOL.

In the Eastern Basin, pumping from more than one shaft may be desirable, depending on the connectivity between some of the compartments and the behaviour of the void water in the main compartments.

## 2.2 Design Capacity of Pumps and Treatment Works

The pump capacities adopted for the STI were based on the principle that the pumps would be sized to pump the average AMD ingress in 19 hours per day, to avoid Eskom's peak tariff periods, or to pump the peak ingress in 24 hours, whichever is the greater. The same principle has been adopted in this Study.

The STI HDS plant has been planned to treat the daily capacity in 19 hours, with only a minimum of mixing and recycling equipment operating during the Eskom peak tariff periods. By contrast, the LTS desalination plant has been planned, in this Study, to operate continuously over 24 hours, as will the sludge disposal and treated water delivery systems. This avoids the need to start and stop the treatment process each day, and reduces the required capacity of the works by operating over a longer period each day.

Whether only the pumps or also the HDS plant operate for 19 hours, the provision of balancing storage between the components working for 19 hours and those operating for 24 hours is required. To provide some redundancy, at least 12 hours' average flow to be provided in two reservoirs of 6 hours equivalent capacity each was allowed for in the Prefeasibility Study. During the Concept Design Stage a more conservative approach was followed and 24 hours balancing storage was allowed for. The proposed capacities of the pumps and treatment works are shown in **Table 2.6**.

**Table 2.6: Proposed capacities of the pumps, treatment works and balancing storage**

Description	Flow rate (Mℓ/day)			Period	Equivalent flow rate (m <sup>3</sup> /s)		
	Western	Central	Eastern		Western	Central	Eastern
Average ingress (Mℓ/day) (no ingress control)	23	46	80	19 hrs	0.336	0.673	1.170
Peak ingress(Mℓ/day)	40	50	100	24 hrs	0.463	0.579	1.157
<b>Adopted Values:</b>							
Pumps (Mℓ/19 hr) Pump peak ingress	32	46	80	19 hrs	0.463	0.673	1.170
Treatment works (peak capacity Mℓ/24 hrs)	40	58	101	24 hrs	0.463	0.673	1.170



Description	Flow rate (Mℓ/day)			Period	Equivalent flow rate (m³/s)		
	Western	Central	Eastern		Western	Central	Eastern
Average flow-through treatment works (Mℓ/day)	23	46	80	19 hrs			
Balancing storage as per Concept Design (Mℓ)	2 x 11.5	2 x 23	2 x 40				

Source: DWA AMD FS 2013, Study Report No. 5 “**Technical Prefeasibility Report**”

## 2.3 Summary of Recommendations

The recommended critical water levels and abstraction shafts are shown in **Table 2.7**.

**Table 2.7: Proposed water control levels**

Description	Abstraction		Critical control levels <sup>1</sup>		
	Shaft name	Collar level (m amsl)	Critical level (m amsl)	TOL (m amsl)	Depth to TOL (m) at abstraction shaft
<b>Western Basin</b>					
Proposed initial (ECL-1)	#8 <sup>4</sup>	1 726	1 600	1 585	141
Conservative (ECL-2)			1 565	1 550	176
<b>Central Basin</b>					
SECL-1 <sup>2</sup>	SWV <sup>5</sup>	1 646	1 474	1 454	192
ECL			1 520	1 500	146
<b>Eastern Basin</b>					
Initial conservative ECL-2	#3 <sup>6</sup>	1 570	1 280	1 280 <sup>3</sup>	290
Probable long-term higher ECL-1			1 470	1 450	120

Note:

<sup>1</sup> Source: DWA AMD FS, 2012: Study Report No. 5.2 “**Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids**”

<sup>2</sup> This level is to keep the mine water level below the historic Gold Reef City Museum (GRCM).

<sup>3</sup> This level is considered to be conservative, and the ECL and TOL are the same.

<sup>4</sup> Rand Uranium (RU) No. 8 Shaft.

<sup>5</sup> South West Vertical (SWV) Shaft.

<sup>6</sup> Grootvlei No. 3 Shaft.

The following are recommended for the abstraction works and treatment works:

- The treatment works should be planned to be able to treat incoming water quality at the 95<sup>th</sup> percentile, but are expected to receive water of a quality between the 50<sup>th</sup> and 75<sup>th</sup> percentiles for much of the time;
- The water quality of the water abstracted from the void by the STI should be monitored very regularly;
- The void monitoring data should be assessed regularly;

- The infrastructure should be designed to handle the expected average flows in 19 hours or the peak flows in 24 hours, whichever is the greater; and
- Cost-effective measures to reduce ingress should be identified and implemented as a matter of urgency, since considerable savings are possible.

## **3. OPTIONS FOR A LONG-TERM SOLUTION**

### **3.1 Introduction**

This section discusses the available options for the technical components of the LTS, apart from the abstraction of AMD which was discussed in Chapter 2. The options identified in these study components fed into the Prefeasibility Phase, where alternative combinations of options were evaluated and a single combination of options for each basin was recommended for further evaluation during the Feasibility Phase.

The technical study components discussed in this section are:

- Options for the use or discharge of AMD, whether it be raw, neutralised or fully treated (neutralised and desalinated) AMD. For more background on this study component, refer to Study Report No. 5.3.
- Assessment of AMD treatment technologies. This section provides an overview of Study Report No. 5.4.
- Options for the sustainable management or use of residue products. This section provides an overview of Study Report No. 5.5.

### **3.2 Options for Use or Discharge of Water**

#### **3.2.1 Introduction**

The options for the use or disposal of water derived from the management of AMD must be evaluated against the backdrop of the river system reconciliation strategies for the Vaal, Olifants and Crocodile (West) River Systems.

The local surface water resources for the Vaal and Crocodile (West) Water Management Areas (WMAs) have been fully exploited for more than three decades. The Vaal River System supplies water to about 60% of the South African economy and 45% of the population. It is therefore crucial to conduct proper planning for the future and optimise the use of the available resources to ensure that all reasonable demands are satisfied.

The neutralised AMD, which will still have high salinity, will be discharged into the Vaal River System once the STI is commissioned in the Central (2014) and Eastern (December 2014) Basins. This will require dilution releases to be made from the Vaal Dam to maintain the water at an acceptable quality. These releases will reduce the available yield of the Vaal Dam and lead to surplus water in the Vaal Barrage and downstream. Even with the earliest introduction of the second phase of the Lesotho Highlands Water Project (LHWP), the Polihali Dam in 2022, there will still be deficits and water restrictions in the Vaal Dam supply area, which could have enormous economic implications.

The Vaal River strategies, which are to be implemented to limit the deficits, are as follows:

- Eradicate unlawful water use, which will reduce the water requirement;
- Implement water conservation and water demand management (WC&WDM) to reduce water use by 15%; and
- Initially address the AMD-related salinity and then address the salinity associated with the other return flows to sustain the current system yield into the future.

Successful implementation of all these strategies would mean that the risk of water restrictions during the planning period, up to 2050, will be minimised.

The Vaal River Strategy also determined that no additional water should be exported from the Vaal River System to the Olifants River System.

### **3.2.2 Cost–Benefit Analysis of Alternative Water Resource Management Scenarios for the Vaal River System**

#### **a. Introduction**

The “**Vaal River System Reconciliation Strategy**” (DWA, 2009) recommended desalination of the AMD from the Central and Eastern Basins and is thus the preferred option for dealing with the salt load from AMD, thus removing it from the Vaal River System rather than accepting higher salinities in the Vaal Barrage and downstream or releasing water from the Vaal Dam to dilute the saline AMD to acceptable levels. That recommendation was based on the information available at the time. This Study has developed current feasibility level cost estimates for abstracting, neutralising and desalinating AMD before it is released to the river or delivered to users. The cost–benefit analyses of three alternative scenarios are presented in the Confidential Study Report No. 7 , together with a qualitative assessment of the impacts that could not be quantified. The results are summarised here. In all three scenarios, the proposed STI to neutralise the AMD, with some reduction in salinity, is assumed to be implemented; and Phase II of LHWP (Polihali Dam) is also assumed to be implemented, with water transfers starting in 2022.

#### **b. Scenario 1: Do Nothing**

No dilution releases will be made from the Vaal Dam and there will be no reduction in the salinity of the AMD through any treatment, after the neutralisation. This will lead to higher salinity levels downstream of the Vaal Barrage and the economic impacts have been assessed. It will also impact on the tributaries from the point where the water is released until it reaches the Vaal Barrage. The cost–benefit analysis (CBA) for this scenario has been conducted for the impact of a range of TDS levels that will occur in the Middle- and Lower-Vaal River. The impacts of the increased flow and salt load from the Vaal River into the Orange River have not been assessed, but are likely to be negative.

### **c. Scenario 2A: Dilution without Early Implementation of the Thukela Water Project**

Once neutralised AMD is released into the river system, continuous dilution releases from the Vaal Dam will be made in order to maintain the Water Quality Objective (WQO) of 600 mg/l in the Vaal Barrage and downstream. The Thukela Water Project (TWP) will not be commissioned until required for normal augmentation (as if dilution releases had not been made), which will be after 2050.

The dilution releases will result in deficits from 2016 until the full annual volume of water is transferred from the LHWP Phase II (Polihali Dam) in about 2022. At that time the deficit will be very small, but will increase due to the increasing demands on the system, until the end of the planning horizon (2050) and beyond. The CBA for this scenario assessed the impact of water restrictions on the users of the Vaal River System and considered the impact of neutralised but saline water on receiving streams.

### **d. Scenario 2B: Dilution with Thukela Water Project Implemented**

This scenario was analysed with the TWP commissioned as soon as possible (2025) to augment the Vaal River System and continuous dilution releases made from the Vaal Dam in order to maintain the WQO of 600 mg/l in the Vaal Barrage.

Deficits will occur from 2016 until the full annual volume of water is transferred from the LHWP Phase II (Polihali Dam) in about 2022. The deficit will increase with increasing demand until 2025 when the TWP is commissioned. In the CBA for this scenario the costs of the TWP are included from 2015 (commencement of design) to allow for commissioning in 2025; the impacts of probable water restrictions were assessed, and the impact of neutralised but saline water on receiving streams was considered.

### **e. Scenario 3: The “Desalination” Scenario**

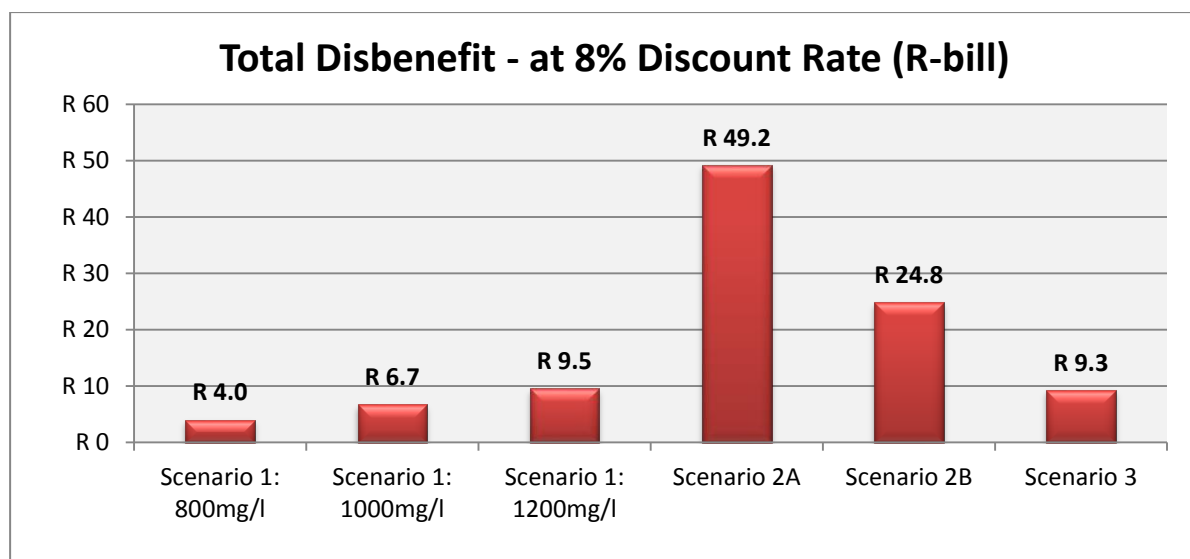
For this scenario, the AMD generated in the Central and Eastern Basins will be neutralised and desalinated. The salinity of the water released into the Vaal River System will be no greater than that of potable water. Desalination would also be implemented in the Western Basin, but the AMD discharges would flow into the Crocodile (West) River System rather than the Vaal River System; the costs for the Western Basin were therefore not included.

Until the LTS is in place (i.e. salinity is addressed), dilution releases from the Vaal Dam will be made in order to maintain the WQO of 600 mg/l in the Vaal Barrage, and some deficits will occur until the dilution is no longer required. The TWP can be delayed until after the end of the planning horizon (2050).

The CBA assessed the impact of discharging neutralised but saline water to receiving streams in the short-term until the LTS is commissioned and the costs of the LTS for the Central and Eastern Basins.

## f. Results

The results of the evaluation of the scenarios are shown in **Figure 3.1**.



**Figure 3.1: Disbenefit to the economy of alternative AMD Scenarios for the Vaal River System**

It is thus clear that the disbenefits of Scenario 2, accelerating the implementation of the TWP, are very high compared with the disbenefit of desalinating AMD, using the Reference Project (Scenario 3). The comparison with Scenario 2 depends on the likely salinity at the Vaal Barrage, which is predicted to vary between less than 800 mg/l and up to 1 250 mg/l at different times, depending on natural inflows. However, neither the negative impacts of salinity on the water users and the receiving streams, nor the impacts of externalising the salts to the Orange River System, have been quantified. The negative impacts of implementing the LTS need to be considered alongside the very significant positive benefits for the economy of Gauteng (through increased Gross Domestic Product (GDP) and job creation), presented in Chapter 8, of implementing the LTS.

### 3.2.3 Water Resource Management Scenarios for the Crocodile (West) River System

A study is currently under way to set Resource Water Quality Objectives (RWQOs), which includes modelling the salt loads from AMD. That study has not yet been finalised, and the RWQOs have not been set. However, the anticipated RWQOs at the point of discharge are likely to be equivalent to potable water standards, requiring desalination to make it acceptable to discharge AMD. The cost of treatment is such that it is uneconomic to discharge water of this quality into the environment, and it is recommended that, for the Reference Project, such water is supplied to Rand Water for use by their consumers.

In the Crocodile (West) River System, the water quality modelling carried out as part of the **“Implementation and Maintenance of the Reconciliation Strategy for the Crocodile West Water Supply System”** (DWA, August 2013) has shown that:

- Discharge of saline AMD into the Tweelopies Spruit upstream of the dolomites will cause a significant increase in the TDS in the already highly saline dolomites and is not recommended; and
- Discharge of saline AMD into the Tweelopies Spruit downstream of the dolomites or into a tributary downstream of Percy Steward Wastewater Treatment Works (WWTWs) would significantly increase the salinity in the receiving streams by 500 to 600 mg/l, as well as increase the salinity in the Hartbeespoort Dam by up to 80 mg/l. It is not recommended.

In conclusion, the dolomites and river system have no assimilative capacity, and any of the scenarios for discharging saline AMD will lead to a marked increase in salinity in the Hartbeespoort Dam. This Study thus recommends that the salts in the AMD be removed, or that the water be used in such a way that the salts will not enter the river system.

### 3.2.4 Options for Use or Discharge of Water

Against the background of the water resource strategies for the Vaal and Crocodile (West) River Systems, a range of options for suitably reducing or removing the salts were considered.

General re-use options for AMD were identified, including options in the domestic, mining, industrial and agricultural sectors.

#### a. Raw (Untreated) AMD

Only one possible alternative was identified and assessed for supplying raw AMD to consumers. Mintails, which operates a gold recovery process in the vicinity of RU No. 9 Shaft in the Western Basin, has developed a process in which they mix raw AMD with the residue from their gold extraction plant. It produces a neutralised water stream and a tailings stream, containing the heavy metals. This process is a very recent development of which the Study Team was made aware only in September 2012. Discussions with the developers have been conducted since then to analyse the process. If acceptable, this process can possibly also be applied to the Central and Eastern Basins by other gold reclaiming companies, depending on the Mintails' licensing conditions and subject to other limitations associated with the Mintails process.

It would be unacceptable to supply raw AMD for any other consumptive purposes, or to discharge raw AMD to the environment. If this were allowed to happen, then this Study, as well as the STI, would altogether fail to achieve their objectives, since the AMD would not have been neutralised; no metals would have been removed; and the high salt loading would still be present.

## **b. Neutralised AMD**

Past research has indicated that neutralised AMD can be used for agriculture in the short to medium-term. Such irrigation has to be properly managed and should only be practised on areas where the soil properties and crops match the requirements. This could, however, pose a risk due to salinity returning to the system. There is a current Water Research Commission (WRC) project which is investigating the potential for using AMD from the Witwatersrand Basins for agriculture (WRC, 2013a).

The use of neutralised AMD by industry is also attractive, because the cost of desalination at source is not incurred. However, this would still pose significant risks to the surface and underground water resources in the study area, since the neutralised AMD would still have a very high salt load. There is no assurance that the users would reduce the salt load in any return flows to acceptable levels before making releases to the environment, or properly manage any salts they might remove from the water. This would pose a direct risk to achieving the Study goal of ensuring long-term water supply security and continual fitness for use of the Vaal River water by removing the salinity from the AMD.

## **c. Neutralised and Desalinated AMD**

Neutralised and desalinated AMD (fully treated) was considered for supply to domestic and industrial users, as well as discharge to the environment. Discharge to the environment has been extensively evaluated and will be acceptable from a purely environmental perspective. However, this option will be far less economically viable, since no revenue will be generated from the sale of fully treated AMD. The proposed discharge points, if discharge to the environment needs to occur, have been identified as:

- Western Basin: Treated AMD should be rerouted to the Percy Steward WWTWs to be discharged with the treated waste water at a less sensitive point in Bloubank Spruit than the current discharge point in the Tweelopies Spruit.
- Central Basin: Treated water should be discharged downstream of the wetland in the Klipspruit.
- Eastern Basin: Treated water should be discharged downstream of the Marievale Bird Sanctuary.

Water users in the Witwatersrand region, that could potentially be users of fully treated AMD, were identified.

Rand Water draws its water from the Vaal Dam, which is augmented by the LHWP, the Sterkfontein and Grootdraai Dams. Rand Water pays the Vaal River Tariff (VRT) for the water they abstract.

Several industrial users were identified that receive water directly from the Vaal River System. These include:

- Eskom, which currently operates 12 coal-fired power stations; three more are being planned. The water requirement scenario that was used in the planning analysis



indicated that the total water demand for all the power stations is expected to increase from 313 million m<sup>3</sup> in 2006 to 397 million m<sup>3</sup> in 2030;

- Sasol, with the Grootdraai Dam, being the primary source of water for the Sasol Secunda Complex, and the Vaal Dam being the primary source of water for the Sasol Sasolburg Complex. The water requirements for the two Sasol complexes combined are expected to increase from 119 million m<sup>3</sup> in 2006 to 166 million m<sup>3</sup> in 2030; and
- Mittal Steel, which receives its water from the Vaal Dam via Rand Water, and was planning to decrease its current water use from 17.4 million m<sup>3</sup>/a in 2006 to 16.6 million m<sup>3</sup>/a in 2010, after which the water use was projected to remain constant for the subsequent years of the planning period.

From the outset of this Study, it has been anticipated that Rand Water would be a key stakeholder in utilising the treated AMD and also in the implementation of the recommended LTS.

Rand Water is the main bulk buyer and supplier of water in the region and supplies about 4.1 million m<sup>3</sup> of treated water per day. Rand Water's municipal customers account for almost 92% (3 767 Mℓ/d) of their total demand, with mining customers adding more than 6% (246 Mℓ/d), industries about 1% (41 Mℓ/d), and all other direct customers accounting for the balance.

Discussions with Rand Water regarding the possible use of desalinated AMD for domestic or industrial use were initiated during 2012. Rand Water have indicated that they are not in favour of supplying any treated AMD to domestic users, since they are wary of the adverse public reaction if such water were introduced into their system. Thus, only the option of industrial use was investigated in further detail and recommended for the Reference Project. Rand Water's **"Water Demand Projection Study"** (Rand Water, 2009) projected growth of 2.14% in water demand up until 2025. Rand Water has current rights to abstract 3 688 Mℓ/d of raw water from the Vaal River Government Scheme, which includes the Vaal Dam. The volume will not be adequate to supply the growth in water demand, and Rand Water is therefore applying to increase the abstraction volumes on the basis of the projected volume of raw water needed to supply consumers.

Rand Water has existing large industrial users and has received applications for more water from industries and mines in the area, which together could use more than the volume of treated AMD that would be available. Rand Water has indicated that they would wish to make the necessary arrangements to supply the water. This is the most economic option and would replace water that would otherwise be supplied from the Vaal River System. The quality of the water required could influence the design of the treatment works for the LTS.

A list of bulk consumers supplied by Rand Water is given in the Study Report No. 5.3.

The quality of water required by various users is discussed in Section 3.3.

### 3.3 Assessment of Technologies for the Treatment of AMD

The previous chapter concluded that it is necessary to provide Primary Treatment to neutralise the AMD, with removal of heavy metals. Secondary Treatment is then required to desalinate the AMD to a standard where it can be safely discharged to the environment or accepted for consumptive use. The suitability of any Primary or Secondary treatment processes depends on the water quality standard required by the environment or users.

In some cases, Tertiary treatment may be appropriate or economically beneficial.

The South African National Standards (SANS), SANS 241: 2012 specifications for domestic supplies have been used as a base case, but various users, including the environment and domestic consumers and industry required or expect higher standards, which are summarised in **Table 3.1**. Treating the full AMD stream through all the phases of treatment would not always be required; the requirement would be to remove only sufficient salts to meet the applicable standards.

**Table 3.1: Summary of standards for various discharges or uses**

Description	Chlorides (mg/ℓ)	Sulphates (mg/ℓ)	TDS (mg/ℓ)
SANS 241 : Acute Health <sup>1</sup> Aesthetic <sup>2</sup>	- 300	500 250	- 1 200
Environment RWQO:			
Western Basin (Tweelopies Spruit)	75	400	481
Central Basin (Klip River) (Low/high)	50/75	200/350	520/650
Eastern Basin (Blesbokspruit) (Low/high)	80/150	150/300	293/455
Rand Water <sup>3</sup>	9-13	13-17	130-230
Industry <sup>4</sup> : Cooling water – current			150
Cooling water - preferred			40
Boiler Feed Water			0.1 - 1

1 Poses an immediate unacceptable health risk if consumed.

2 Taints water with respect to taste, odour and colour, but that does not pose an unacceptable health risk.

3 From Rand Water website for period 22 June to 22 July 2011 (average  $\pm$  3 standard deviations). Water supplied to Johannesburg Metropolitan Municipality. Assumes that industrial customers are supplied via the same network.

4. Data from Sasol.

The management of the residues produced by each of the treatment is as important as the capability of a treatment process to produce water of the required standard. The residues need to be managed indefinitely and require extensive disposal sites. It is also important that the substances formed are adequately stable so as not to become a source of environmental pollution. The stability of the waste products, as well as the volumes produced, are therefore a major criterion in the selection of the treatment processes for the LTS.

There are various biological, chemical and physical technologies available that can be used for the neutralisation and then desalination of AMD. Most of the processes, however, do not remove the monovalent ions such as Sodium (Na) and Chloride (Cl) from the water, and hence, some form of Reverse Osmosis (RO) is required in all instances where the monovalent ions in the feed AMD exceed the required standards for the treated water. This

supplementary or tertiary treatment could be added with relative ease to each of the secondary processes that do not meet the required standard.

An important factor to be taken into account in the assessment is the level of development of a technology. In this Study, the technologies have been classified into one of three levels of development (*i.e.* laboratory scale, pilot scale and proven technologies). Of all the technologies investigated, only the HDS process for neutralisation and removal of metals, the conventional RO process for desalination and Ion Exchange for the removal of Uranium or metals, can, at present, be classified as proven technologies. These processes have been implemented in plants at a large scale with treatment capacities that are comparable with the capacities required for the treatment of AMD in the Witwatersrand.

The volumes to be managed to address the AMD problem in the Witwatersrand are currently some of the largest volumes of AMD in the world. Nowhere have plants for other technologies been constructed to treat the volumes present in the Witwatersrand. South Africa is thus embarking on untested territory. However, it would be inappropriate to ignore technologies merely because there are no installations of comparable size. There could be a significant reduction in the production of waste products if other processes in each of the categories can be proved suitable and then employed at full scale:

- Physical processes other than conventional RO;
- Biological processes; and
- Chemical processes.

A process that reduces the production of waste products, and produces differentiated residues with a commercial value, would reduce the problems associated with their disposal. This would have a major influence on the economics of the operation, especially when the indefinite horizon of the problem is taken into account.

The roles that other technologies could play and their cost effectiveness must be considered in detail. However, the owners of the intellectual property related to many of the processes, understandably, keep it very confidential, and it is difficult to obtain adequate information to fully evaluate the processes and their costs. The advantages of some of the process, however, appear to be very attractive, thus warranting further research, and some companies are testing small-scale, prototype plants in the Western Basin at present.

It is proposed that promising processes be evaluated in detail by constructing Pilot Treatment Plants with the capacity to treat between 5 and 10 Ml/d in order to refine the process, understand the operational risks when working at this scale and demonstrate the suitability of the processes. This is discussed further in Chapter 12.

The capacity of the biological processes to treat the required volume of AMD is restricted by the available organic material. The total volume of sludge produced in the south of Johannesburg and on the East Rand by the WWTWs is inadequate to treat all the AMD from the Central and Eastern Basins. Additional sources of organic material would have to be

identified and sourced, and there is a current WRC project (WRC, 2013b<sup>1</sup>) to investigate the suitability of alternative sources.

AMD water is rising in the basins; the discharge of saline water will compromise the water resources of the Vaal and Crocodile (West) River Systems, affecting the economics of Gauteng and other provinces, and urgent action is required. There is no time left for experimentation to develop optimal solutions before implementing a medium-term (10 – 15 years) desalination plant. It is recommended that proven technologies are used, noting that the solution that is implemented, might later be shown to have contained some element of non-optimal expenditure. This fact has to be accepted, as time for further investigations has run out.

The criteria for selecting technologies for the Reference Project were thus technologies that:

- Can treat the AMD to standards that would, as far as possible, allow use of the treated water to potential users;
- Produce waste products that do not create an environmental risk through their disposal;
- Preferably produce waste products in a form that they have re-use value;
- Are proven to be reliable;
- Are sustainable; and
- Are the optimal from the environmental, operational, and cost perspectives.

The only treatment processes that can be implemented with an acceptable degree of risk are the HDS process, followed by conventional RO. Ion Exchange, which is an expensive process, can be included in the process train, to remove Uranium or metals, if the cost is justified by the benefits of removing the Uranium and selected metals and possibly recovering them for commercial use. Ion Exchange has been allowed for in the costing of the Reference Project. This process train was considered in detail, as all the associated risks can be addressed, and costs have been assigned to the elimination of the risks. This is the base case, for at least the medium term (10 to 15 years), against which all other processes can be compared and measured. This base case has high operating costs and produces large volumes of sludge, which is expensive to dispose of, and in the longer term, it may be shown that it is not the best long-term solution if some of the other technologies prove themselves.

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<sup>1</sup> The BIOSURE Process: A sustainable, long-term treatment option for acid mine drainage treatment.

## 3.4 Options for the Sustainable Management or Use of Residue Products

### 3.4.1 Introduction

The disposal of sludge from the HDS plants proposed for the STI and the disposal of sludge and brine from the conventional RO plants, proposed for the LTS, at least in the medium term, will have a significant cost. This section discusses the conceptual siting, sizing and costing of the required facilities, which are described in more detail in Study Report No. 5.5.

### 3.4.2 Sludge

The STI proposals for sludge disposal in each basin at the time of the investigations were only short to medium-term options (West Wits Pit (WWP) in the Western Basin and co-disposal with tailings in the Central and Eastern Basins). Co-disposal with tailings is also an option in the medium-term for the LTS, but will depend on reaching agreements with the mining companies operating the tailings facilities. The LTS has therefore made provision for all the sludge from the HDS and RO plants, from the time of commissioning the LTS in each basin.

The sludge from the treatment processes can only be classified in terms of the minimum requirements for landfill, (DWAF, Third Edition, “**Waste Management Series. Minimum Requirements for Waste Disposal by Landfill**” (DWAF, 2005), once the treatment process are confirmed, the plants are in production and samples can be analysed.

It is possible that, under current guidelines and legislation, the sludge could be classified as general waste. However, in terms of the draft waste classification management legislation (DEA, 2012), which is being prepared, the sludge would almost certainly be classified as hazardous. The size of the sites required means that the applicable design standards are essentially the same as those for hazardous waste. For the purpose of planning and costing, it has been assumed that the sludge will be classified as hazardous. However, the Environmental Impact Assessment (EIA) for a hazardous waste site is likely to be more protracted with very strong public reactions. The volumes of sludge to be managed (at the 75<sup>th</sup> percentile water quality) are given in **Table 3.2**.

**Table 3.2: Quantities of sludge to be managed**

	Units	Western Basin	Central Basin	Eastern Basin
HDS	m <sup>3</sup> /d	100.3	56.6	42.6
RO	m <sup>3</sup> /d	43.0	163.5	157.8
<b>Total</b>	m <sup>3</sup> /d	143.3	220.1	200.4

*Note: The volumes given are at 65% solids.*

The volumes given in **Table 3.2** are at 65% solids as it has been assumed that the sludge in the Sludge Storage Facility (SSF) will, in the long term, be at 65% solids.

Various potential sites for SSFs were identified for each long-term AMD treatment plant. A desk-top study and site selection were conducted at each site. This involved identifying sites for each basin in close proximity to the alternative treatment works. These sites were evaluated according to the “**Minimum Requirements for Waste Disposal by Landfill**” (DWAF, 2005), and the most suitable sites (or the least undesirable, as the case might be) were selected. Site selection can only be finalised in discussion with the Local Authorities (LAs) and in parallel with, the required EIAs and geotechnical investigations.

For the Western Basin, two alternative locations for residue disposal facilities were investigated namely, the Western Basin near the RU Shaft No. 8 and the Western Basin Tunnel outlet near the Percy Steward WWTWs. In the Central Basin, three possible residue disposal facility locations were investigated namely, the Central Basin near the SWV Shaft, Central Basin Tunnel: Option 1 and Central Basin Tunnel: Option 2. Only one location was investigated for the Eastern Basin in the vicinity of Grootvlei No. 3 Shaft.

SSF on the preferred site would be constructed incrementally over time, using downstream wall-raising methods, as the HDS sludge is known to be incapable of being used to build its own impoundment walls. Waste rock is considered for the wall-building, as large quantities seem to be readily available in reasonable proximity to each site.

For each selected SSF option, taking geometric constraints into consideration, an optimum area-to-height relationship was developed for the expected sludge quantities. Conceptual sizing, as well as capital, operating and closure costs were determined. A summary of the conceptual sizes and cost estimates is provided in **Table 3.3**.

**Table 3.3: Summary of size and cost estimates**

Parameter	Western Basin	Western Basin Tunnel	Central Basin	Central Basin Tunnel: Option 1	Central Basin Tunnel: Option 2	Eastern Basin
Final perimeter length	800 m	1 090 m	1 090 m	1 090 m	1 090 m	938 m
Final perimeter width	660 m	665 m	665 m	665 m	665 m	613 m
Final height	10 m	10 m	10 m	10 m	10 m	14 m
Capacity	2.6 million m <sup>3</sup>	2.6 million m <sup>3</sup>	3.9 million m <sup>3</sup>	3.9 million m <sup>3</sup>	3.9 million m <sup>3</sup>	3.5 million m <sup>3</sup>
Capital costs	R 282 million	R 344 million	R 398 million	R 398 million	R 399 million	R 278 million
Operational cost/year	R 11.8 million	R 14.1 million	R 14.4 million	R 14.4 million	R 16.7 million	R 15.6 million
Total operational costs over life	R 530 million	R 635 million	R 650 million	R 650 million	R 750 million	R 700 million
Closure costs	R 65 million	R 65 million	R 67 million	R 67 million	R 67 million	R 71 million
<b>Total costs</b>	<b>R 877 million</b>	<b>R 1 044 million</b>	<b>R 1 115 million</b>	<b>R 1 115 million</b>	<b>R 1 216 million</b>	<b>R 1 049 million</b>

*Note: Although some of the facilities are similar in size, the costs differ because of different haul distances for the waste rock used for the construction.*

Due to the onerous long-term management of the SSFs, as well as the cost and environmental impacts, there is a strong case for considering alternative treatment options that create less residue or residues from which saleable products can be separated. Processes such as Ion Exchange that remove contaminants cause the waste to be classified as hazardous, but which may have a commercial value, should be considered on the basis of economics in the implementation phase. Investigations into alternatives to disposal in landfills should be investigated for the long term.

### **3.4.3 Brine**

The desalination process produces brine, the volume of which is directly proportional to the salts in the incoming water and the standard required for the product water.

The following possible options have been identified for the disposal of brine from desalination of the neutralised AMD:

- Engineered lined evaporation ponds;
- Co-disposal with the sludge; and
- Marine disposal near Durban, using a redundant pipeline belonging to Transnet with a new three to four kilometre long diffuser pipe into the sea.

These are discussed in Study Report No. 5. Co-disposal with sludge was used in the options analysis. However, for the Concept Design (Study Report No. 6) and the Reference Project, as planned to be, brine will be disposed of in engineered lined evaporation ponds. This would result in the salts being retained in the lined storage facility and the liquids evaporating. The ponds will each comprise two compartments, the operational and one drying out prior to removal and disposal of the salt.

## **3.5 Summary of Options**

The following options were recommended to be combined into complete solutions for Prefeasibility assessment, which is discussed in Chapter 4.

- i) Water use or discharge:
  - Discharge to the environment;
  - Supply for local potable use;
  - Supply to Rand Water for local industrial use; and
  - Supply to remote industrial users (mines and Sasol).
- ii) Treatment technology - The technologies considered in the options analysis are:
  - HDS for neutralisation;
  - Conventional RO for desalination;
  - A biological process (although not proven) if treated near a WWTW, to assess costs; and



- Ion Exchange as an additional process, if economically viable, was not considered in the options analysis because it would be common to all options.

iii) Residue management:

- HDS and RO sludge to SSF; and
- Co-disposal brine to the SSF, since this was common to all options. It did not influence the evaluation. (Note: separate provision was made for brine disposal in evaporation ponds in the Concept Design and Reference Project).



## 4. PREFEASIBILITY SELECTION OF OPTIONS FOR FEASIBILITY LEVEL ASSESSMENT

### 4.1 Introduction

The Prefeasibility Phase of the Study (Study Report No. 5) considered various combinations of the alternative abstraction points, treatment processes, waste disposal options, and alternative end-users for the treated water for each basin. The various options considered as elements of the 47 options are shown in **Tables 4.1, 4.2** and **4.3** for the Western, Central and Eastern Basins, respectively. In those tables, the elements are shown in the combinations selected for economic analysis. After an initial screening on the basis of feasibility, 12 options in total for all three basins were selected for further consideration, as shown in the tables.

**Table 4.1: Components considered in the Western Basin**

Option	Abstraction	Neutralisation	Desalination	Sludge disposal	Water use / disposal
W1.1.1.1	Rand Uranium Shaft No. 8	New HDS Plant	Conventional RO	New SSF with supernatant return	Blougatspruit downstream of Percy Steward WWTW
W1.1.1.3a	Rand Uranium Shaft No. 8	New HDS Plant	Conventional RO	New SSF with supernatant return	Rand Water infrastructure for distribution
W1.1.1.3b	Rand Uranium Shaft No. 8	New HDS Plant	Conventional RO	New SSF with supernatant return	Platinum mines (Remote industrial use)
W2.2.3.1	Rand Uranium Shaft No. 8 and gravity tunnel to Blougatspruit	-	BIOSURE plus Biosulphur	Biological sludge. Metal sulphides and sulphur to market	Blougatspruit downstream of Percy Steward WWTW

**Table 4.2: Components considered in the Central Basin**

Option	Abstraction	Neutralisation	Desalination	Sludge disposal	Water use / disposal
C1.1.1.1	SWV Shaft	HDS	Conventional RO	New SSF with supernatant return	Elsburgspruit downstream of wetland
C1.1.1.3	SWV Shaft	HDS	Conventional RO	New SSF with supernatant return	Domestic or local industrial use
C1.1.1.3a	SWV Shaft	HDS	Conventional RO	New SSF with supernatant return	Remote industrial use (Secunda)
C2.1.1.1	Tunnel from SWV Shaft	HDS	Conventional RO	New SSF with supernatant return	Elsburgspruit downstream of wetland
C2.1.1.3	Tunnel from SWV Shaft	HDS	Conventional RO	New SSF with supernatant return	Domestic or local industrial use
C5.1.1.3a	Multiple boreholes	HDS at SWV Shaft	Conventional RO	New SSF with supernatant return	Domestic or local industrial use

**Table 4.3: Components considered in the Eastern Basin**

Option	Abstraction	Neutralisation	Desalination	Sludge disposal	Water use / disposal
E1.1.1.1	Grootvlei No. 3 Shaft	HDS	Conventional RO	New SSF with supernatant return	Blesbokspruit downstream of wetland
E1.1.1.3	Grootvlei No. 3 Shaft	HDS	Conventional RO	New SSF with supernatant return	Domestic or local industrial use
E1.1.1.3a	Grootvlei No. 3 Shaft	HDS	Conventional RO	New SSF with supernatant return	Remote industrial use (Secunda)

These options are described in Sections 4.3 to 4.5 and the recommendations are given in Section 4.6.

## 4.2 Approach to Economic Assessment of Selected Options

All costs have been estimated at the base date of March 2012. Capital costs have been estimated, using the most applicable data obtained from recent tender prices, generally as an all-in rate (e.g. R/km of pipeline). Energy costs have been estimated based on average pumping heads with tariff increases of 16% per annum (10% above inflation) for the next three years. Thereafter, electricity costs are assumed to increase with normal inflation. Chemicals consumption is based on the water quality at the 75<sup>th</sup> percentile. The consumption of energy and chemicals and the cost of brine disposal are based on treating the water to the (SANS) 241 standards. If better water quality is required, the costs will increase.

It has been assumed that major maintenance of the mechanical and electrical components will be needed every 15 years at a cost of 15% of the cost of pumps and motors. Other annual Operation and Maintenance (O&M) costs are estimated as a percentage of capital costs, using values typical of the Department's works, as shown in **Table 4.4**. O&M costs for SSFs have been calculated, including the construction of the perimeter wall with rockfill from the nearest mine waste dump. It has been assumed that the rock is available free of charge. Haulage of rock has been included.

**Table 4.4: O&M costs per annum as percentage of capital costs**

Element	Percentage
Pump stations:	
• Mechanical and electrical	4%
• Civil	0.25%
Pipelines	0.5%
Tunnel	0.25%

Based on preliminary information from Rand Water, incomes of R 5/m<sup>3</sup> and R 8/m<sup>3</sup> have been used for water supplied to domestic and industrial users, respectively.

Life-time costs over 50 years, at 2012 rates, have been discounted to 2012 at 8% per annum. Unit Reference Values (URVs) were used as a proxy for the cost–benefit of the option and have been calculated by dividing the discounted present value of costs by the discounted volumes of water treated, assuming the current estimated daily volumes are abstracted for the full period.

It has been assumed that construction will commence in 2015 and that operational costs will begin in 2016.

Although the cost estimates are at a Prefeasibility level of accuracy, many of the options have similar components. Thus, the relative costs of the options will have less uncertainty than the absolute costs. Where options with significantly different components have similar URVs, sensitivity analyses can be used to test the implications of variations in the cost of elements which are not common.

## **4.3 Assessment of Selected Options for the Western Basin**

### **4.3.1 Desalination and Release to River**

#### **a. Motivation**

Option W1.1.1.1 was selected to provide a base case since it has the lowest cost of any of the options that include abstraction by pumping and desalination.

#### **b. Description**

- i) Abstraction from RU No. 8 Shaft, as for the STI;
- ii) Primary treatment by HDS, as for the STI, followed by desalination by Conventional RO to SANS 241 Standards;
- iii) Sludge and brine (waste) disposal from the HDS plant will be to a new SSF located just south of the Rustenburg Road, with a supernatant return system to the treatment works; and
- iv) Desalinated water discharged into the Tweelopies Spruit, as for the STI.

#### **c. Key Parameters for Assessment**

**Table 4.5** shows the estimated Capital Expenditure (CAPEX) and Operating Expenditure (OPEX) costs of Option W1.1.1.1.

**Table 4.5: CAPEX and OPEX – Option W1.1.1.1**

	Option W1.1.1.1	Capital cost <sup>3</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	48	5	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	530 288	36 71	Minimal	Minimal
iii)	Treated water disposal (STI) <sup>2</sup>	-	0	Continuous flow in river Water quality not quite to RWQO	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return system	39 118 35	1 29 0	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 058</b>	<b>142</b>		

Note:

1 Capital costs as supplied by TCTA in November 2012.

2 Link to STI pipe included in desalination.

3 Base date of March 2012.

The Net Present Value (NPV) of capital and running costs, discounted at 8% per annum to March 2012, amounts to R 2 262 million, giving a URV of R 20/m<sup>3</sup>. This includes the capital and operating costs of the STI.

#### 4.3.2 Desalination for Domestic or Local Industrial Use

##### a. Motivation

Option W1.1.1.3a was costed to include the costs of local distribution infrastructure required to transfer the fully treated water from the treatment works to the nearest Rand Water reservoir, which was assumed to be a suitable node for distribution.

Although Rand Water has advised that they are not in favour of accepting the treated AMD into their potable distribution network, this option provides an indication of cost for supplying the water to any new user or to a suitable node for reticulation to users for industrial use.

##### b. Description

- i) Abstraction from RU No. 8 Shaft, as for the STI;
- ii) Primary treatment by HDS or possibly Mintails, as for the STI. This will be followed by desalination by Conventional RO to SANS 241 Standards;
- iii) Waste disposal to a new SSF located just south of the Rustenburg Road, with a supernatant return system to the treatment works; and
- iv) Desalinated water supplied to the nearest Rand Water reservoirs or distribution node at that point.

### c. Key Parameters for Assessment

**Table 4.6** shows the estimated CAPEX and OPEX costs of Option W1.1.1.3a.

**Table 4.6: CAPEX and OPEX – Option W1.1.1.3a**

	Option W1.1.1.3a	Capital cost <sup>1</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI)	48	5	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) Desalination (RO)	530 288	33 69	Minimal	Minimal
iii)	Treated water supply infrastructure	100	2	Minimal	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return system	39 118 35	1 29 0	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 158</b>	<b>139</b>		
	<b>Income from domestic water sales<sup>2</sup> @ R 5/m<sup>3</sup></b>		42		
	<b>Income from industrial water sales<sup>2</sup> @ R 8/m<sup>3</sup></b>		67		

Notes:

1 Base date of March 2012.

2 Assumes SANS 241 water qualities are acceptable.

The NPV of capital and running costs, discounted to March 2012 at 8% p.a., amounts to R 2 347 million, giving a URV of R 21/m<sup>3</sup>. This includes the capital and operating costs of the STI, but excludes the income from water sales.

If the income from domestic water sales is included, the URV will be R 16/m<sup>3</sup>. If the income from local industrial water sales is included, the URV will be R 13/m<sup>3</sup>.

### 4.3.3 Desalination for Industrial Use at Marikana

#### a. Motivation

Option W1.1.1.3b has been included, as Rand Water has indicated that this is their preferred option, because they are not in favour of accepting treated AMD in their potable water system and details of any local industrial users were not available from Rand Water.

#### b. Description

- i) Abstraction from RU No. 8 Shaft, as for the STI;
- ii) Primary treatment by HDS or possibly Mintails, as for the STI. This will be followed by desalination by Conventional RO to SANS 241 Standards;
- iii) Waste disposal to a new SSF located just south of the Rustenburg Road, with a supernatant return system to the treatment works; and

- iv) Desalinated water supplied to platinum mines. The end point assumed to be at Marikana.

### c. Cost

**Table 4.7** shows the estimated CAPEX and OPEX costs of Option W1.1.1.3b.

**Table 4.7: CAPEX and OPEX – Option W1.1.1.3b**

	Option W1.1.1.3b	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	48	5	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	530 288	36 69	Minimal	Minimal
iii)	Treated water supply infrastructure	504	10	Minimal River crossings	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	39 118 35	1 29 0	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 562</b>	<b>150</b>		
	<b>Income from water sales @ R 8/m<sup>3</sup></b>		67		

Note:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

The NPV of capital and running costs, discounted to March 2012, amounts to R 2 733 million, giving a URV of R 34/m<sup>3</sup>. This includes the capital and operating costs of the STI, but excludes the income from water sales.

## 4.3.4 Tunnel with Desalination and Release to River

### a. Motivation

A tunnel option, W2.2.3.1, has been considered as it will allow AMD to be abstracted from the mine void by gravity, rather than by pumping up a shaft.

### b. Description

- i) Abstraction could be through a horizontal tunnel just below the TOL. For a tunnel with inlet invert at 1 575 m amsl and outlet invert at 1 578 m amsl, a 6.9 km long tunnel could discharge into the Blougatspruit just downstream of the Percy Steward WWTW. The design of the tunnel is beyond the scope of this Study, but the following factors have been considered:

- The tunnel should be designed to flow full under all conditions, and the discharge should be controlled at the downstream end to provide a constant flow to the treatment works. This will result in the water level in the shaft varying within the freeboard allowance utilising balancing storage in the mine void.
- Whether the tunnel connects directly to RU Shaft No. 8, or elsewhere, the mine void needs further consideration, but a shorter tunnel is possible.
- The tunnel would be driven from the northern (downstream) end. To avoid having to break into the mine/shaft under water, it is proposed that the water level in the mine be drawn down by the STI pumps to below the tunnel level before tunnel construction.
- To minimise tunnel length, the tunnel should slope upwards in the downstream direction, despite the more complicated construction conditions.
- Once the tunnel is commissioned, the STI pumps and the neutralisation facilities from the immediate and/or STI would become redundant. The pumps and the treatment equipment can be retained as standby for similar pumps in the other basins.
- The saving in electricity costs by abstracting the AMD by gravity is estimated at R 4.1 million per annum for the proposed TOL, with a NPV of R 105 million for a 50-year lifespan.

ii) Treatment:

The location of the tunnel outlet, close to the Percy Steward WWTW, indicates the adoption of a biological treatment process, using sludge from the WWTWs as carbon source with a biosulphur process. Costs were based on information received from BIOSURE. The volumes of sludge from the Percy Steward WWTW are altogether inadequate, and it is assumed that sludge is also brought from the Randfontein and Flip Human WWTWs to the site.

However, only about 50% of the carbon required would be available. The remaining carbon requirements would have to be obtained from other sources of waste that are high in carbon. Possible options are dairy waste, blood from abattoirs or maize silage. It is assumed that the costs of transporting the sludge from the WWTW and the other waste to the works would be equivalent to saving costs by eliminating the need to dispose of the sludge from all three treatment works.

Treated water from the biological treatment would be discharged down the Blougatspruit, together with the effluent from the existing Percy Steward WWTW; and

The options of supply to Rand Water for consumptive use can be considered by Rand Water.

iii) Waste disposal: It was assumed that the biological sludge resulting from the process would be disposed of at a cost similar to that for HDS and RO. Elemental sulphur from

the Biosulphur process would be available for sale, but because of the lack of information about the market, no income has been assumed from this source.

### c. Cost

**Table 4.8** shows the estimated CAPEX and OPEX costs of Option W2.2.3.1.

**Table 4.8: CAPEX and OPEX – Option W2.2.3.1**

	Option W2.2.3.1	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	STI pumps (Redundant) <sup>1</sup>	48	0		
ii)	Abstraction (tunnel)	280	1	Minimal	Minimal
iii)	Treatment: HDS (STI – redundant) <sup>1</sup> BIOSURE, Biosulphur & Sand Filter	530 345	0 50	Limited	Limited
iv)	Neutralised water disposal (STI)	0	0	Continuous flow in river Water quality not quite to RWQO	Minimal
v)	Waste disposal: Sludge	177	46	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 380</b>	<b>96</b>		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

It is noted that the capital cost of biological treatment is more than that of RO, and the economics of each should be compared.

The NPV of capital and running costs, discounted to March 2012, amounts to R 2 015 million, giving a URV of R 18/m<sup>3</sup>. This includes the capital costs of the STI, which will become redundant.

## 4.4 Assessment of Selected Options – Central Basin

### 4.4.1 Desalination and Release to River

#### a. Motivation

Option C1.1.1.1 has been included, as it is expected to be the least-cost solution when considered in isolation. The water will be returned to the Vaal River, where it can be extracted by other users further downstream. While this will contribute to reducing the high salt loads in the river, it should be borne in mind that this option must be compared with other options that deliver similar quality treated water to other users at a relatively high altitude. The income from those options is included in the assessment of those options.



**b. Description**

- i) Abstraction from the SWV Shaft, as for the STI;
- ii) Primary treatment by HDS, as for the STI, followed by RO desalination to SANS 241 Standards;
- iii) Waste disposal to a new SSF; and
- iv) Desalinated water discharged into the Elsburgspruit, as for the STI.

**c. Cost**

**Table 4.9** shows the estimated CAPEX and OPEX costs of Option C1.1.1.1.

**Table 4.9: CAPEX and OPEX – Option C1.1.1.1**

	Option C1.1.1.1	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	20	11	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	382 382	64 154	Minimal	Minimal
iii)	Treated water disposal	-	-	Continuous flow in river Water quality not quite to RWQO	Minimal
iv)	Waste Disposal: Sludge pipeline SSF Supernatant return	97 117 105	1 36 1	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 103</b>	<b>267</b>		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

The NPV of capital and running costs, discounted to March 2012, amounts to R 2 382 million, giving a URV of R 16/m<sup>3</sup>. This includes the capital and operating costs of the STI.

**4.4.2 Desalination for Domestic or Local Industrial Use****a. Motivation**

Although Rand Water has indicated that they are not in favour of accepting treated AMD into their potable water system, option C1.1.1.3 has been costed to indicate the implications of not using treated AMD as water for consumptive use so that the economics of this option can be compared with other options. It also provides an indication of the bulk infrastructure to supply local industries, although their locations are not yet known.

## b. Description

- i) Abstraction from the SWV Shaft, as for the STI;
- ii) Primary treatment by HDS, as for the STI, followed by RO desalination to SANS 241 Standards;
- iii) Waste disposal to a new SSF; and
- iv) Desalinated water supplied to the Rand Water reservoirs, which could also be nodes for the distribution of industrial water.

## c. Cost

**Table 4.10** shows the estimated CAPEX and OPEX costs of Option C1.1.1.3.

**Table 4.10: CAPEX and OPEX – Option C1.1.1.3**

	Option C1.1.1.3	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	20	11	Nothing new – Existing	Nothing new – Existing
ii)	Treatment:				
	Neutralisation HDS (STI) <sup>1</sup>	382	64	Minimal	Minimal
	Desalination (RO)	382	154		
iii)	Desalinated water disposal (STI)	196	11	Minimal	Minimal
iv)	Waste disposal:				
	Sludge pipeline	97	1	Minimal	Land-use
	SSF	117	36	Brownfields	Visual
	Supernatant return	105	1	Site	Safety
	<b>Total cost</b>	<b>1 299</b>	<b>278</b>		
	<b>Income<sup>3</sup> from potable water sales @ R 5/m<sup>3</sup></b>		84		
	<b>Income<sup>3</sup> from industrial water sales @ R 8/m<sup>3</sup></b>		134		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

3 Assumes SANS 241 water qualities are acceptable.

The NPV of capital and running costs, all discounted to March 2012, amounts to R 3 284 million, giving a URV of R 19/m<sup>3</sup>. This includes the capital and operating costs of the STI, but excludes the income from water sales.

## 4.4.3 Desalination for Industrial Use at Secunda

### a. Motivation

Option C1.1.1.3a has been included, as Rand Water has indicated that this is their preferred option since they do not favour accepting treated AMD into their potable water system, and they have a number of potential industrial users that could use all this water. Sasol has independently indicated that they can use all the water from both the Central and Eastern Basins at the Sasol Synfuels complex in Secunda, or possibly from the Central Basin at the

Sasol Infrachem complex in Sasolburg. The latter option was not considered, because the energy used to raise the water to the surface would be dissipated in the transfer to Sasolburg. For this option, the cost of pumping the Central Basin water to the Eastern Basin treatment works, as well as a pro rata portion of the cost of the pipeline from the Eastern Basin to Secunda, were included.

## b. Description

- i) Abstraction from the SWV Shaft, as for the STI;
- ii) Primary treatment by HDS, as for the STI, followed by RO desalination to SANS 241 Standards;
- iii) Waste disposal to a new SSF; and
- iv) Desalinated water supplied to the Eastern Basin, from where it will be pumped to Secunda.

## c. Cost

**Table 4.11** shows the estimated CAPEX and OPEX costs of Option C1.1.1.3a.

**Table 4.11: CAPEX and OPEX – Option C1.1.1.3a**

	Option C1.1.1.3a	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	20	11	Nothing new – Existing	Nothing new – Existing
ii)	Treatment:				
	Neutralisation HDS (STI) <sup>1</sup>	382	64	Minimal	Minimal
	Desalination (RO)	382	154		
iii)	Treated water supply infrastructure	317	9	Minimal	Minimal
iv)	Waste disposal:				
	Sludge pipeline	97	1	Minimal	Land-use
	SSF	117	36	Brownfields	Visual
	Supernatant return system	105	1	site	Safety
v)	Pro rata cost of pipeline from Eastern Basin to Secunda	565	33	See Table 4.17	See Table 4.17
	<b>Total cost</b>	<b>1 985</b>	<b>309</b>		
	<b>Income<sup>3</sup> from water sales @ R 8/m<sup>3</sup></b>		134		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

3 Assumes SANS 241 water qualities are acceptable.

The NPV of capital and running costs, all discounted to March 2012, amounts to R 4 055 million, giving a URV of R 23/m<sup>3</sup>. This includes the capital and operating costs of the STI, but excludes the income from water sales.

#### 4.4.4 Tunnel with Desalination and Release to River

##### a. Motivation

A tunnel could abstract water mainly by gravity, with some pumping, but still saving substantial pumping costs (Option C2.1.1.1).

##### b. Description

- i) Abstraction: A horizontal tunnel from the SWV Shaft to operate at the TOL of 1 454 m amsl associated with an SECL of 1 474 m amsl to protect the GRCM at 5 Level at 1 484 m amsl would discharge near Vereeniging, requiring a 50 km long tunnel because of the flat topography. This is obviously not a viable solution.

However, the tunnel invert could be set at 1 550 m amsl, and the AMD pumped from the TOL (1 454 m amsl) to the tunnel inlet, with a static head of 96 m. A 7.5 km long tunnel could discharge by gravity into Elsburgspruit just upstream of where it is crossed by the N3 highway;

- ii) Treatment would be by HDS and RO;  
iii) Waste disposal would be to a new SSF with supernatant return system; and  
iv) Desalinated water would be discharged into the Elsburgspruit, as for the STI.

##### c. Cost

**Table 4.12** shows the estimated CAPEX and OPEX costs of Option C2.1.1.1.

**Table 4.12: CAPEX and OPEX – Option C2.1.1.1**

	Option C2.1.1.1	Capital cost <sup>3</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction: STI pumps (Redundant) <sup>1</sup> Tunnel with pumping	20 393	- 11	Spoil dump	Minimal
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	774 382	64 154	Minimal	Minimal
iii)	Treated water disposal <sup>2</sup>	-	-	Continuous flow in river Water quality not quite to RWQO	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	81 117 92	1 36 1	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 859</b>	<b>229</b>		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Discharge infrastructure to river included in Desalination.

3 Base date of March 2012.

The NPV of capital and running costs, discounted to March 2012, amounts to R 3 499 million, giving a URV of R 20/m<sup>3</sup>. This includes the capital costs of the STI, which would become redundant.

#### 4.4.5 Tunnel with Desalination for Domestic or Industrial Use

##### a. Motivation

As for the previous option, but with the high costs partially offset by income from water sales for domestic or industrial use (Option C2.1.1.3).

##### b. Description

- i) Abstraction: As for the previous option, a horizontal tunnel from the SWV Shaft, with the TOL at 1 454 m amsl, would have a tunnel at 1 550 m amsl, and AMD would be pumped from the TOL to the tunnel inlet, with a static head of 96 m;
- ii) Treatment would be by HDS and RO;
- iii) Waste disposal would be to a new SSF with supernatant return system; and
- iv) Treated water would be supplied to the existing Rand Water reservoir at Meyerton. This could also be a node for distribution of water to local industrial users.

##### c. Cost

**Table 4.13** shows the estimated CAPEX and OPEX costs of Option C2.1.1.3.

**Table 4.13: CAPEX and OPEX – Option C2.1.1.3**

	Option C2.1.1.3	Capital cost <sup>3</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction: STI pumps (Redundant) <sup>1</sup> Tunnel with pumping	20 393	- 11	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI redundant) <sup>1</sup> Desalination (RO)	764 382	64 154	Minimal	Minimal
iii)	Treated water disposal <sup>2</sup>	164	11	Minimal	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	81 117 92	1 36 1	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>2 013</b>	<b>278</b>		
	<b>Income from domestic water sales @ R 5/m<sup>3</sup></b>		84		
	<b>Income from industrial water sales @ R 8/m<sup>3</sup></b>		134		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Discharge infrastructure to river included in desalination.

3 Base date of March 2012.

The NPV of capital and running costs, discounted to March 2012, amounts to R 3 703 million, giving a URV of R 21/m<sup>3</sup>. This includes the capital costs of the STI, which would become redundant, but excludes the income from water sales.

## 4.4.6 Multiple Boreholes for Abstraction

### a. Motivation

In the event of poor connectivity along the 55 km length of the basin, multiple extraction points from boreholes have been considered (Option C5.1.1.3a).

### b. Description

- i) Abstraction: Six submersible borehole pumps, each pumping 10 Ml/d, with another two as standby. Pumps to be of duplex stainless steel. A 50 km long pipeline varying in diameter from 300 mm at the western end to 700 mm at the eastern end of the basin would convey raw AMD to the treatment site. This is a conservative option, as a significant portion of the water could still be abstracted from the SWV Shaft, reducing the number of boreholes and pipe length required;
- ii) Treatment by HDS and RO at the STI site;
- iii) Waste disposal to a new SSF with supernatant return system; and
- iv) Desalinated water will be supplied to the Eastern Basin, from where it will be distributed or for domestic use pumped by Sasol to Secunda.

### c. Cost

**Table 4.14** shows the estimated CAPEX and OPEX costs of Option C5.1.1.3a.

**Table 4.14: CAPEX and OPEX – Option C5.1.1.3a**

	Option C5.1.1.3a	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction: STI pumps (Redundant) <sup>1</sup> Boreholes (six) Pumps (eight) Pipeline to treatment works at SWV	20 14 138 15	- 0 12 0	Minimal	Minimal
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	382 382	64 154	Minimal	Minimal
iii)	Treated water supply infrastructure	317	9	Continuous flow in river Water quality not quite to RWQO	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return system	97 117 105	1 36 1	Minimal Brownfields site	Land-use Visual Safety
	Pro rata cost of pipeline from Eastern Basin to Secunda	565	33		
	<b>Total cost</b>	<b>2 152</b>	<b>310</b>		
	<b>Income from water sales @ R 8/m<sup>3</sup></b>		134		

Notes:

1 Capital cost as supplied by TCTA in November 2012. In practice, the pumps would still be used for some abstraction.

2 Base date of March 2012.

The NPV of capital and running costs, discounted to March 2012, amounts to R 4 188 million, giving a URV of R 24m<sup>3</sup>. This includes the capital costs of the STI, which would become redundant, but excludes the income from water sales.

## 4.5 Assessment of Selected Options – Eastern Basin

### 4.5.1 Desalination and Release to River

#### a. Motivation

Option E1.1.1.1 was selected to provide a base case, since it has the lowest cost of any of the options, including abstraction by pumping and desalination.

#### b. Description

- i) Abstraction from Grootvlei No. 3 Shaft, as for the STI;
- ii) Treatment by HDS, as for the STI, plus desalination by conventional RO;
- iii) Desalinated water discharged into the Blesbokspruit downstream of the Ramsar wetland via a new 5.1 km long 800 mm pipe; and
- iv) Waste disposal to a new SSF just across the Blesbokspruit from the abstraction and treatment point.

#### c. Cost

**Table 4.15** shows the estimated CAPEX and OPEX costs of Option E1.1.1.1.

**Table 4.15: CAPEX and OPEX – Option E1.1.1.1**

	Option E1.1.1.1	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	22	23	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	522 606	70 127	Minimal	Minimal
iii)	Treated water disposal	254	9	Continuous flow in river Water quality not quite to RWQO	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	30 159 31	2 46 2	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 624</b>	<b>279</b>		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012

The NPV of capital and running costs, discounted to March 2012, amounts to R 3 993 million, giving a URV of R 14/m<sup>3</sup>. This includes the capital and operating costs of the STI.

## 4.5.2 Desalination for Domestic or Local Industrial Use

### a. Motivation

Although Rand Water has indicated that they are not in favour of accepting treated AMD into their potable water system, option E1.1.1.3 has been costed to enable the economic comparison with other options to be made. In this case, however, it has been assumed that the water will be supplied directly to a nearby municipal reservoir, which will require a shorter pipeline and less pumping than supplying to a Rand Water reservoir.

This option also provides an indication of the cost of supplying to a node for reticulation to local industrial users.

### b. Description

- i) Abstraction from Grootvlei No. 3 Shaft, as for the STI;
- ii) Treatment by HDS, as for the STI, plus desalination by RO;
- iii) Desalinated water supplied to the nearest Rand Water or large municipal reservoirs; and
- iv) Waste disposal to a new SSF just across the Blesbokspruit from the abstraction and treatment point.

### c. Cost

**Table 4.16** shows the estimated CAPEX and OPEX costs of Option E1.1.1.3.

**Table 4.16: CAPEX and OPEX – Option E1.1.1.3**

	Option E1.1.1.3	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	22	23	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	522 606	70 127	Minimal	Minimal
iii)	Treated water supply infrastructure	257	16	Minimal	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	30 159 31	2 46 2	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>1 627</b>	<b>286</b>		
	<b>Income<sup>3</sup> from domestic water sales @ R 5/m<sup>3</sup></b>		146		
	<b>Income<sup>3</sup> from industrial water sales @ R 8/m<sup>3</sup></b>		234		

Notes:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

3 Assumes SANS 241 water qualities are acceptable.

The NPV of capital and running costs less projected income, discounted to March 2012, amounts to R 4 067 million, giving a URV of R 14/m<sup>3</sup>. This includes the capital costs of the



STI, but excludes the income from water sales. This URV may be low, since the costs of treating to a higher standard than SANS 241 are not included.

### 4.5.3 Desalination for Industrial Use at Secunda

#### a. Motivation

Rand Water has indicated that they are not in favour of accepting treated AMD into their potable water system, but that they have a number of potential industrial users that could use all this water.

Sasol has independently indicated that they can use all the water from both the Central and Eastern Basins at Secunda. For this option (E1.1.1.3a), the cost of pumping the water from the Eastern and Central Basins to Secunda has been added.

#### b. Description

- i) Abstraction from Grootvlei No. 3 Shaft as for the STI;
- ii) Treatment by HDS, as for the STI, plus desalination by RO;
- iii) Desalinated water supplied to Rand Water, at the treatment works or to Sasol at Secunda, together with water from the Central Basin; and
- iv) Waste disposal to a new SSF just across the Blesbokspruit from the abstraction and treatment point.

#### c. Cost

**Table 4.17** shows the estimated CAPEX and OPEX costs of Option E1.1.1.3a.

**Table 4.17: CAPEX and OPEX – Option E1.1.1.3a**

	Option E1.1.1.3a	Capital cost <sup>2</sup> (R million)	Running costs R million / annum	Ecological impact	Social impact
i)	Abstraction (STI) <sup>1</sup>	22	23	Nothing new – Existing	Nothing new – Existing
ii)	Treatment: Neutralisation HDS (STI) <sup>1</sup> Desalination (RO)	522 606	70 127	Minimal	Minimal
iii)	Treated water supply infrastructure Less pro rata share for Central Basin water	1 547 -565	44 -33	River crossing	Minimal
iv)	Waste disposal: Sludge pipeline SSF Supernatant return	30 159 31	2 46 2	Minimal Brownfields site	Land-use Visual Safety
	<b>Total cost</b>	<b>2 352</b>	<b>281</b>		
	<b>Income<sup>3</sup> from water sales @ R 8/m<sup>3</sup></b>		234		

Note:

1 Capital cost as supplied by TCTA in November 2012.

2 Base date of March 2012.

3 Assumes SANS 241 water qualities are acceptable.

The NPV of capital and running costs, discounted to March 2012, amounts to R 4 606 million, giving a URV of R 16/m<sup>3</sup>. This includes the capital costs of the STI, but excludes the income from water sales. This URV may be low, since the costs of treating to a higher standard than SANS 241 are not included.

## 4.6 Comparison of Options and Recommendations

### 4.6.1 Introduction

Following this options assessment, the Reference Projects in each basin were selected based on satisfying the key drivers, namely:

- Using abstraction points with good connectivity to the entire basin at as shallow a level as practical to ensure that the ECL/SECL is protected with the highest practical TOL;
- Determining the highest ECL or SECL to minimise pumping costs and protect shallow aquifers and infrastructure;
- Identifying acceptable users/uses for the treated water (the treatment will also result in the removal of salts from the Vaal and Crocodile (West) River Systems);
- Utilising the Reference Treatment processes to meet the requirements of users;
- Providing opportunities to develop innovative technologies that may be effective and reliable in the long term;
- Utilising as much infrastructure as appropriate from the STI; and
- Providing the most economical solution that is socially and environmentally acceptable.

### 4.6.2 Western Basin

The costs and URVs for the options selected and described in the previous sections are summarised in **Table 4.18**.

**Table 4.18: Western Basin – Comparison of selected options**

	Option	Capital cost <sup>1</sup> (R million)	O&M <sup>3</sup> (R million/a)	URV <sup>2</sup> (R/m <sup>3</sup> )	Income (R million/a)	Income (R/m <sup>3</sup> )
W1.1.1.1	Desalination by RO to river	1 058	142	20	0	0
W1.1.1.3a	Desalination by RO for: Domestic use Local industrial use	1 158	139	21	42 67	5 8
W1.1.1.3b	Desalination by RO for remote industrial use	1 562	150	34	67	8
W2.2.1.1	Tunnel abstraction with biological treatment and discharge to river	1 380	96	18	0	0

Notes:

TOL = 1 585 m amsl

1. Cost base date of March 2012.

2. URV at March 2012 at 8% discount rate.

3. Energy tariffs estimated at 10% above inflation for 3 years to 2015.

Based on these costs, it is concluded that:

- The most economic option (lowest URV), excluding the economic benefit of the treated water, is option W2.2.1.1;
- The option with the lowest capital and second-lowest operating costs is desalination to the river, but as this option does not realise any economic benefit from the treated water, it is not recommended;
- The three remaining options entail desalination for either domestic or local industrial use. However, the distance to the platinum mines, which are the likely recipients of the industrial water, makes this option significantly more expensive in terms of upfront capital and operating costs. If local industrial users can be identified, then the higher selling price would make this the best option;
- It is therefore clear that, if local industrial users cannot be found, Rand Water's reluctance to accept fully treated AMD water for domestic use could incur additional capital costs of R 404 million and additional operating costs of R 11 million per annum if local industrial users cannot be found; and
- It is recommended that a conventional RO plant at RU Shaft No. 8 be adopted as the Reference Project, with the end-user of the treated water being determined through negotiation between the Department and Rand Water.

#### 4.6.3 Central Basin

The costs and URVs for the options selected and described in the previous sections are summarised in **Table 4.19**.

**Table 4.19: Central Basin – Comparison of selected options**

	Option	Capital cost <sup>1</sup> (R million)	O&M <sup>3</sup> (R million/a)	URV <sup>2</sup> (R/m <sup>3</sup> )	Income (R/m <sup>3</sup> )	Income (R million/a)
C1.1.1.1	Desalination to river	1 103	267	16	0	0
C1.1.1.3	Desalination for: Domestic use Local industrial use	1 299	278	19	5 8	84 134
C1.1.1.3a	Desalination to EB for remote industrial use <sup>4</sup> Plus share of pipeline to Secunda	1 420 565	276 33	19 4		134 -
	<b>TOTALS</b>	1 985	309	23	8	134
C2.1.1.1	Tunnel with desalination to river	1 859	229	17	0	0
C2.1.1.3	Tunnel with desalination for: Domestic use Local industrial use	2 013	278	21	5 8	84 134
C5.1.1.3a	Multiple boreholes to remote industrial use	2152	310	24	8	134

Notes:

TOL = 1 454 m amsl.

1. Cost base date of March 2012.

2. URV at March 2012 at 8% discount rate.

3. Energy tariffs estimated at 10% above inflation for 3 years to 2015..

4. Excludes pro rata cost of transferring the water from the Central to the Eastern Basin, which is shown separately but includes the full revenue from Central Basin water.

Based on these costs, it is concluded that:

- The option with the lowest capital and operating costs is the discharge of desalinated water to the river, but because this option does not generate any income from water sales, it is not recommended;
- The option of supplying water for domestic use to the nearest Rand Water reservoir has a higher URV than the option of discharging to the river, but the capital costs are R 686 million lower than the option of supplying to remote industrial users. However, if this water can be sold for industrial use at a similar distance from the treatment works, then the higher selling price makes this a preferred option;
- The two tunnel options have the highest capital and operating costs, and even after allowing for possible income from water sales, offer no benefits; and
- The option of abstracting water from multiple boreholes increases the capital costs by R167 million, but provides a viable back-up option if the connectivity of the basin is found to be inadequate.

The choice of option for the Central Basin must be made together with the decision regarding the Eastern Basin.

However, the recommended preliminary Reference Project is abstraction from SWV Shaft, neutralisation by HDS, desalination by conventional RO, and delivery of water to local industries.

#### 4.6.4 Eastern Basin

The costs and URVs for the options selected and described in the previous sections are summarised in **Table 4.20**.

**Table 4.20: Eastern Basin – Comparison of selected options**

	Option	Capital cost <sup>1</sup> (R million)	O&M <sup>3</sup> (R million/a)	URV <sup>2</sup> (R/m <sup>3</sup> )	Income (R/m <sup>3</sup> )	Income (R million /a)
E1.1.1.1	Desalination to river	1 624	279	14	0	0
E1.1.1.3	Desalination for: Domestic use Local industrial use	1 627	286	14	5 8	146 234
E1.1.1.3a	Desalination for industrial use (Includes full pipeline to Secunda)	2 917	314	20	-	234
	Less Central Basin's pro rata share of pipe to Secunda	-565	-33	-4	-	0
	<b>Total</b>	<b>2 352</b>	<b>281</b>	<b>16</b>	<b>6</b>	<b>234</b>

Notes:

TOL = 1 280 m amsl.

1. Cost base date of March 2012.

2. URV at March 2012 at 8% discount rate.

3. Energy tariffs estimated at 10% above inflation for 3 years to 2015.

Based on these costs, it is concluded that:

- The option with the lowest capital and operating costs is again desalination to the river, but because this option brings in no revenue, it is not recommended;
- If industrial users nearer to the basin can be found, then that option will have the lowest URV unless the distribution infrastructure is very expensive. That option would be preferable. However, the selection of an option must also take into account options for the Central Basin because of benefits of scale.
- The option of supplying water for domestic use to the nearest municipal reservoir has similar operating costs to supplying to Secunda, but has far lower capital costs. This is a strong motivation for adopting this option despite Rand Water's reservations about accepting water derived from AMD for domestic use. If local industrial users can be found at about the same distance or less than the closest municipal reservoir, then this would be the preferred option.
- The option with the next lowest URV, after deducting the costs of the Central Basin's share of the cost of transporting the water to Secunda is the option of supplying industrial water to Secunda, despite this option having the highest capital costs, but this can only be justified if Sasol makes significant capital contributions.

The selected preliminary Reference Project is thus desalination at Grootvlei No. 3 Shaft, with supply to the end-user by Rand Water still to be confirmed. The final solution must consider including Central Basin water in the delivery system.



## **5. WESTERN BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE**

### **5.1 Introduction**

The identified preliminary Reference Project, described in Chapter 4, formed the basis for the Concept Development part of the Study, during which the sizing, infrastructure component, layout and siting of all elements of the Reference Project were developed in sufficient detail to prepare a Feasibility level cost estimate of the Reference Project.

Since the Reference Project is situated at RU Shaft No. 8, where the abstraction and HDS treatment for the STI are planned, it is appropriate that those components form part of the Reference Project. These cost estimates are based on the CAPEX for the STI having been incurred and financed, and the plant being well operated until the Reference Project is commissioned. At that time, the operation and associated OPEX become part of the LTS.

### **5.2 The Short-Term Intervention**

In the Western Basin, the existing temporary pumps and the planned permanent pumps, and AMD pump station are located at Rand Uranium Shaft No. 8, which lies approximately 1.5 km to the west of the R28 (Main Reef Road), south of Rustenburg Road and east of North Way Road.

The shaft was used for the abstraction of mine water for many years. It has two conveyances, one of which is currently occupied by pipes and temporary pumps for the abstraction of AMD to the existing Rand Uranium treatment plant / Immediate Works to the west of Shaft No. 8. The STI will install new permanent pumps in the remaining conveyance. The permanent pumps will each have a capacity of 33 Mℓ/19-hour day when pumping from the conservative TOL of 1 550 m amsl. The long-term pumps are also suitable for maintaining the initial ECL and TOL.

TCTA is discussing the proposal received from Mintails, and this may be implemented instead of the upgrade to 40 Mℓ/d and the addition of a clarifier.

### **5.3 The Reference Project**

The Reference Project comprises the following elements:

#### **5.3.1 Abstraction Points**

RU Shaft No. 8 was chosen as the pumping site for the STI. The connectivity of the shaft has been shown to be satisfactory. There are obstructions on different shaft compartments that are highlighted in the TCTA Report (2011), and the pumps must be installed in an acceptable compartment. It is understood that this is being addressed by the detailed design

team for the STI. The long-term shaft stability must be monitored with appropriate instrumentation, and regular condition inspections must be carried out.

### 5.3.2 Critical Levels and Target Operating Levels

In the Western Basin where the mine void water is at or very close to surface at Black Reef Incline (BRI), the objective is to eliminate or reduce the risk of polluting the springs feeding from the Tweelopies Spruit and polluting the subsurface flow to the Zwartkrans Compartment dolomitic aquifer that hosts the Cradle of Humankind. It is anticipated that this will be achieved if the mine void water is prevented from entering the dolomitic aquifer via the Black Reef Mine workings at approximately 1 610 m amsl. Therefore, an ECL of 1 600 m amsl is proposed.

In the long term, it is anticipated that a freeboard (or 'buffer') of 15 m should be adequate, and a TOL of 1 585 m amsl is recommended. The water should be held at that level for an appropriate duration to allow the water level in the entire void to drain down to that level and establish whether the water quality downstream in the Tweelopies Spruit is free of pollution from AMD.

No SECL is currently envisaged for the Western Basin.

It has been recommended that a TOL of 1 585 m amsl for an ECL of 1 600 m amsl be maintained for an appropriate time, between 1 and 2 years, while surface water quality in the lower reaches of Tweelopies Spruit is monitored. If the pollution ceases, the ECL can be maintained at this level. If the pumping to a TOL of 1 585 m amsl has been shown to be appropriate to protect the ECL, the TOL can be maintained at that level. If the 15 m freeboard proves to be too conservative or insufficient to protect the ECL, the TOL should be adjusted.

Balancing storage is provided between the abstraction at Shaft No. 8 and the treatment works.

If the pollution does not cease, then the ECL and TOL should be progressively lowered in 5 m increments every 6 months until pollution in the downstream springs and Tweelopies Spruit ceases and can be maintained during pumping, to maintain a 15 m freeboard below the ECL. A long-term ECL of 1 565 m amsl and TOL of 1 550 m amsl are recommended.

### 5.3.3 Pumps and Pumping Rates

It is proposed that a one duty and one standby pump configuration will be adopted. Each pump will have a capacity to pump 30 Mℓ/d in a 19-hour day with the TOL at 1550 m amsl.

RU has been abstracting water from Shaft No. 8 and treating it at their adjacent neutralisation plant, using two submersible pumps with a capacity of 8 Mℓ/d each, but the capacity of their pumps and treatment works was inadequate to manage the total flow from the entire basin. TCTA has ordered new Tinstall (a new Ritz Model) HDM 67 37.3/8 pumps, to be commissioned in March 2014 and replace the existing pumps once the water level has



been reduced to the TOL. At the proposed long-term TOL of 1 585 m amsl, the installed capacity will be 30 Mℓ/19-hour day, operating 19-hour day, which will be adequate to maintain the water level under average conditions and can be increased by about 25% by operating the pumps 24 hours/day, if necessary.

It is proposed that all the pumps and associated equipment be retained to form part of the LTS.

### 5.3.4 Treatment Works

The proposed works comprise:

- Disposal of brine to evaporation ponds to be constructed at the same site as the HDS plant;
- Long-term primary treatment by High Density Sludge (HDS) for neutralisation, as provided by the STI;
- Balancing storage reservoirs will be provided between the abstraction plant and the first stage of the treatment neutralisation plant and desalination plant, storing 24 hours of water production in two lined earth dams, each with a capacity of 11 500 m<sup>3</sup>;
- Provision for an Ion Exchange plant for the removal of Uranium between the balancing storage and the HDS neutralisation plant; and
- Desalination by Conventional RO on the same site as the HDS with further balancing storage for treated water, storing 16 hours of water production in a concrete reservoir with two compartments, measuring 45 m in diameter and 10 m deep.

The main attributes for the selected treatment site at the Rand Uranium Shaft No. 8 are:

- The treatment plant will be located south of the existing tailings on Rand Uranium grounds;
- The LTS will be on the same site as the STI, and there is enough open land to accommodate the required infrastructure; and
- Access roads to the site will be provided by the STI.

### 5.3.5 Residue Management

#### a. Sludge

Sludge from both the neutralisation plant and the desalination plants will be pumped to a new purpose-built SSF through a 6.8 km long High-Density Polyethylene (HDPE) pipeline of 180 mm diameter. A 600 mm parallel HDPE return water pipe will be provided to return polluted rainwater falling on the SSF to the treatment works, and is sized to accommodate a 200-year recurrence interval storm event.

Infrastructure required for the disposal of sludge includes a sludge pump station; and a pipeline to the SSF at Farm Waterval.

A suitable area has been identified for the Western Basin SSF. The site has the following advantages:

- Relatively flat or gently sloping terrain;
- Close to existing tailings dam, so the site would not impose on prime development property;
- Reduced visual impact, as the tailings dam is already there; and
- There is an existing road following the existing railway line to provide access.

The following limitations, however, have to be managed:

- The facility has to be placed so as to avoid the existing railway line and power line, as well as underlying dolomites;
- The concept design for the sludge pipeline was based on a 180 mm diameter HDPE PN16 pipe. The pipeline has to be placed above ground on pedestals where practical, and along existing roads for maintenance purposes, as scaling is expected. A detailed topographical survey along the pipeline route will be required before carrying out the detailed design; and
- Return water from the SSF has to be managed and pumped back to the treatment works. The concept design is based on pumping through a 630 mm diameter HDPE PN12 pipe. The pipeline route will have to follow the same route as the sludge pipeline.

#### **b. Brine**

- Brine from the desalination plant will be pumped to new evaporation ponds. Two ponds, each measuring 82 000 m<sup>2</sup> by 2 m deep, will be provided, the second pond being for use when the first is closed for salt removal or for maintenance.

### **5.3.6 Water Users Location and Infrastructure**

To deliver the treated water to the end-user, a 6.6 km long 600 mm diameter steel pipeline has been provided to the edge of the basin, where it has been assumed that the end-users will take delivery of the water and make their own arrangements to transfer the water to where it is required.

The end-users of the treated water must still be confirmed, but will probably be one or more industrial users described in Study Report No. 5.3.

The Concept Design is based on a 600 mm diameter steel pipeline from the treatment plant to the basin boundary. There are power lines and railway lines in the vicinity of the pipeline, and a corrosion protection system might be required.

### **5.3.7 Geotechnical Assessment**

A Desktop Study revealed the following:

- The ground at the treatment site is underlain by the Jeppestown Group of the Witwatersrand Supergroup, comprising shale, quartzite and lava;

- Excavations are likely to be soft to intermediate; and
- From the published geological maps, a small portion of the site identified for SSF is underlain by Malmani dolomites with the majority underlain by rocks of the Black Reef Formation. A geotechnical investigation should be carried out to confirm the location of the dolomite. The final site could be moved as necessary to avoid the dolomites.

### 5.3.8 Environmental Assessment

The following findings were noted:

#### a. Treatment Site

- The land is not being used actively for agriculture, so a significant land use impact is not expected;
- The land is not listed as environmentally sensitive in terms of the Gauteng Department of Agricultural and Rural Development's (GDARD) Conservation Plan (CPlan); and
- This ridge on the eastern part of the site is expected to be a transformed ridge, with little ecological value, and is not viewed as a significant project risk. This must be confirmed through a dedicated site inspection by a suitably qualified ecologist.

#### b. Sludge Storage Facilities (SSFs)

- The proposed placement currently avoids environmentally sensitive features; micro-adjustments will have to be made during the detail design of the SSF in order to optimise the placement; and
- Best practice design standards with regard to liners and water management for the facility must be used to ensure the prevention of surface and shallow groundwater pollution.

### 5.3.9 Traffic Impact Assessment

The traffic impact of the LTS in the area will be negligible. A new access road to the plant will be designed and constructed under the STI.

## 5.4 Conclusion

The recommendations for implementation in the Western Basin are summarised below. It should be noted that some of the recommendations are already being implemented:

- i) Ensure that the immediate solution continues to stop the decant and slowly reduces the level of water in the mine void;
- ii) Continue the upgrade of the Gold One neutralisation plant to 40 Mℓ/d and install a clarifier;
- iii) Partner with Mintails so that the raw AMD is neutralised in their Tailings Treatment System (TTS) and the waste is disposed of on their planned TSF;
- iv) Install the STI (long-term) pumps with a 30 Mℓ/19-hour average capacity at a level that will allow the TOL of 1 550 m amsl to be maintained if necessary;

- v) Reduce the level of water in the void to a TOL of 1 585 m amsl (ECL 1 600 m amsl), and maintain it at that level for 12 months, while monitoring surface and near-surface water quality in areas previously contaminated by AMD, believed to have been emanating from the decant into the Tweelopies Spruit;
- vi) If pollution has ceased and the TOL has proved suitable to protect the ECL, maintain the TOL at 1 585 m amsl;
- vii) If pollution of surface and near-surface water resources is still evident, reduce the TOL to 1 550 m amsl and continue monitoring;
- viii) Adjust the TOL, based on the monitoring results, to prevent pollution and minimise pumping costs;
- ix) Plan, design and construct the ancillary works, including raw water pipelines, balancing storage, treated water pipelines, brine storage facilities and SSF required to support the Pilot Treatment Plants (PTPs);
- x) Determine a suitable business model in terms of sources of funding, from either the public or private sector, or a combination, for implementation of Pilot Treatment Plants;
- xi) Invite proposals from the private sector to supply, install, commission, operate and maintain PTP that can treat a minimum of 5 Ml/d and a maximum of 10 Ml/d to SANS 241 standards or better for 5 to 7 years. The PTP can use incoming feed water, comprising either:
  - Neutralised AMD, delivered from either the HDS plant associated with the Immediate Works, or from Mintails' TTS; or
  - Raw AMD delivered from the “long-term” pumps.

Details of waste disposal and delivery points to be defined, and responsibilities for funding the CAPEX and OPEX determined.

- xii) Monitor the performance of the PTP, and prequalify those that prove to be acceptable to participate in the next procurement phases of managing AMD in each of the three basins;
- xiii) Carry out a Prefeasibility Study of the gravity tunnel option and alternative treatment processes, and if appropriate, proceed to a full Feasibility Study;
- xiv) By 2018, commence the process to procure a DBOM or DBOMF (PPP) contract with the lowest whole-life cost for the abstraction, treatment, residue management and delivery of water to an end-user, using a proven process for a period of 25 years; and
- xv) Procure new contracts for another 25 years.

## **6. CENTRAL BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE**

### **6.1 Introduction**

The identified preliminary Reference Project, described in Chapter 4, formed the basis for the work during the Concept Development part of the Study, during which the sizing, infrastructure component, layout and siting of all elements of the Reference Project were developed in sufficient detail to prepare a Feasibility level cost estimate of the Reference Project.

Since the Reference Project is situated at RU Shaft No. 8, where the abstraction and HDS treatment for the STI are planned, it is appropriate that those components form part of the Reference Project. These cost estimates are based on the CAPEX for the STI having been incurred and financed, and the plant being well operated until the Reference Project is commissioned. At that time, the operation and associated OPEX become part of the LTS.

### **6.2 The Short-Term Intervention**

In the Central Basin, the AMD abstraction pump station provided by the STI is located at the SWV Shaft at ERPM.

The agreement with Central Rand Gold (CRG) to install the “long-term” pumps with capacity of 46 Ml/d (average for pumping 19 hours/day), or maximum capacity of 58 Ml/d when operated for 24 hours/day in SWV Shaft has been concluded. Commissioning is due before the water level reaches the TOL ECL of 1 500 m amsl recommended for the LTS.

The construction of an HDS neutralisation plant with capacity of 46 Ml/d average for 19 hours/day operation at SWV Shaft commenced in January 2013 and is due to be ready for commissioning in November 2013 and RfO in January or February 2014. The contract included a 3.6 km long pipeline to transfer the sludge to the Knights plant and the existing infrastructure would have been used to convey the sludge to Ergo’s super TSF for co-disposal. However, this option has encountered some difficulties and investigations are on-going to identify a suitable site for disposal of the HDS and if possible, the sludge from the LTS.

### **6.3 The Reference Project**

#### **6.3.1 Abstraction Points**

The Central Basin poses some potential connectivity challenges. The SWV Shaft was chosen for the STI, but it does have risks due to the connectivity at 24 Level though a single haulage.

#### **a. South West Vertical (SWV) Shaft**

For the Central Basin, the SWV Shaft at ERPM was identified in the TCTA Study (2011) as the site where the pumps will be installed. A possible disadvantage of this shaft is that its shallowest connection with the ERPM mine void is at 24 Level, 1 080 mbs. The AMD from all the other compartments will decant from west to east through connections at relatively shallow depths. All the water will decant into the ERPM compartment at about 575 mbs. Due to the compartmentalisation of the Central Basin, it is likely that only relatively shallow water will be drawn towards ERPM from the west and the deep mine water in the west and central parts of the basin will remain undisturbed.

The haulage at 24 Level will have to carry the entire void discharge, and a collapse could restrict the flow. Water would then be drawn up the SWV Sub-shaft, which is connected to the void at the much deeper 39 Level and below. Water will then be drawn from considerable depth if this occurs. This study considers the SWV Shaft to be suitable for at least the medium term (10 to 15 years). It is believed that drawing water from great depths would prolong flushing of the void.

Alternatives that could be used in the future, should a connectivity problem arise, would be boreholes drilled at various locations.

### **6.3.2 Critical Levels and Target Operating Levels**

For the Central Basin, the ECL is based on keeping the AMD at a depth of 100 m below surface at the anticipated decant points of ERPM, Cinderella East and Cinderella West Shafts, at 1 620 m amsl to protect the shallow weathered aquifers and the groundwater regime feeding springs and base flow in streams.

In the long term, a freeboard or buffer of 20 m is expected to be adequate to protect the ECL. The recommended TOL is thus 1 500 m amsl. However, due to the size of the basin (55 km across), there are a number of unknowns, including how the water levels in the mine void will vary, both spatially and temporally, so an initial freeboard of 50 m is recommended, with a TOL of 1 470 m amsl, which corresponds with the STI proposal.

The SECL was pegged at 1 474 m amsl to protect the GRCM at 1 484 m amsl on 5 Level. The TOL can be maintained at 1 454 m amsl, providing a 20 m freeboard. Consideration can be given to relocating the museum to a higher level (2 Level), which is at 1 624m amsl, and raising the pumping level to reduce lifecycle costs.

### **6.3.3 Pumps and Pumping Rates**

Two Ritz HDM submersible pumps have been ordered, each with capacity of 28 Mℓ per 19-hour day at a head of 427 m.

### 6.3.4 Treatment Works

Balancing storage reservoirs will be provided between the abstraction pumps and the first stage treatment works, storing 24 hours of water production in two lined earth dams, each measuring 80 m by 60 m and 5 m deep.

An Ion Exchange plant will be incorporated between the balancing storage and the neutralisation plant, which will be provided as part of the STI.

An RO desalination plant will be provided after the neutralisation plant with further balancing storage for treated water, storing 16 hours of water production in a concrete reservoir with two compartments, measuring 62.5 m in diameter and 10 m deep.

The main attributes of the site located at SWV Shaft are:

- The site will be located on the same site as the STI, which is currently under construction;
- The land is generally flat;
- Platforms can be constructed from material from commercial sources;
- Other essential services such as potable water and access roads will have been provided by the STI; and
- Balancing storage will be provided.

### 6.3.5 Residue Management

#### a. Sludge

Sludge from both the HDS plant and the desalination plant will be pumped to a new purpose-built SSF through a 17.8 km long 180 mm diameter HDPE pipeline. A 600 mm parallel HDPE return water pipe will be provided to return polluted rainwater falling on the SSF to the treatment works, sized to accommodate a 200-year recurrence interval storm event.

The main residues are expected to be sludge from the HDS plant and RO process, and brine from the RO process. It is possible that some residues will have a commercial value and will be sold to, or at least collected by, users.

The Reference Project provides for a dedicated SSF to be constructed as part of the LTS. A number of possible sites have been identified. Based on the volume of sludge expected to be produced over 45 years, the predicted final size of the SSF is 1 090 m by 665 m by 10 m high.

A suitable SSF site has been identified for the Central Basin. The site offers the following advantages:

- Gently sloping terrain;
- Large unutilised area close or adjacent to existing tailings dam; therefore the visual impact would be reduced; and
- Will not make use of prime property.

The following limitations, however, exist:

- Close to private airport, with associated bird strike issues for aircraft;
- The concept design was based on pumping the combined sludge from the HDS and RO processes to the new SSF, and pumping return water from the SSF back to the treatment works; and
- The return water pipeline will follow the same route as the sludge pipeline.

#### **b. Brine**

Suitable land was identified on the Farm Driefontein for brine evaporation ponds. The site has the following characteristics:

- The area slopes gently on either side of Elsburgspruit;
- There is a power line traversing the site; and
- The brine will have to be pumped from the main treatment works to the identified site.

It is recommended that the brine that is produced be disposed of in evaporation ponds, which are low tech and have low operating costs. Two ponds each measuring 460 m by 340 m and 2 m deep are proposed, the second being for use when the first is closed for salt removal or for maintenance.

### **6.3.6 Water Users Location and Infrastructure**

The Reference Project assumes that water from the Central Basin will be pumped to the Eastern Basin treatment site for distribution to end-users. It is recommended that DWA negotiate with Rand Water to secure an end-user agreement for collecting the water at the Central Basin Treatment Works.

The concept design for the sludge pipeline is based on a 17 800 m long 180 mm diameter HDPE PN16 pipe. The pipeline route passes through a built-up environment that includes several road and rail crossings. The pipeline should be above ground for maintenance purposes. A detailed topographical survey is required to establish the parameters of these structures and existing servitudes.

To deliver the treated water to the end-user, a 35.8 km long steel pipeline, with diameter ranging from 700 to 800 mm, has been provided to the Eastern Basin treatment site at Grootvlei Shaft No. 3, where it will be combined with treated water from the Eastern Basin for transfer to the end-users.

The major findings for the pipeline route are summarised below:

- The pipeline is 35.8 km long;
- The pipeline runs through a built up environment, and several road and rail crossings will be encountered. These can be addressed using pipe jacking; and
- There are a number of power lines in the vicinity of the route; corrosion protection will thus be required.



### 6.3.7 Geotechnical Assessment

A Desktop Study revealed the following:

- The treatment site is underlain by the Turffontein Group (comprising quartzite, conglomerate and shale);
- The SSF site is underlain by rocks of the Vryheid formation, Dwyka Group and Black Reef Formation; and
- The evaporation pond site is underlain by the Turffontein Group, which comprises mainly quartzite, conglomerate and shale.

### 6.3.8 Environmental Assessment

The following findings were noted:

- The site is located within existing urban developments and on a brownfields mine site. It is therefore defensible in terms of ecological impact;
- The land in question is not actively used, so a significant land use impact is not expected; and
- The land in question is not listed as environmentally sensitive in terms of GDARD's CPlan.

#### a. Sludge Storage Facility

- Best practice design standards with regard to liners and water management for the facility will be used to ensure the prevention of surface and shallow groundwater pollution.

#### b. Evaporation Ponds

- As evaporation will be the method of disposal, the inherent risk and expected environmental impacts are low; and
- Stormwater management issues will require specific attention at the design stage in order to reduce and manage the environmental risks.

### 6.3.9 Traffic Impact Assessment

The area around the treatment site is an industrial area, and additional traffic due to the LTS will be negligible.

## 6.4 Conclusions

The recommendations for implementation in the Central Basin are summarised below. It should be noted that some of the recommendations are already being implemented:

- i) The programme for implementation of the STI is such that it will probably not be commissioned in time to prevent breaching the SECL of 1 474 m amsl;

- ii) Advise the GRCTF so that they can consider their options, such as vacating the underground GRCM on 5 Level and either reinstating it after the water level drops, or relocating the GRCM to a higher level;
- iii) During construction of the STI, review the current monitoring programme, and recommend any required strengthening. The monitoring programme should include monitoring the water levels in the mine void at agreed locations across the basin, testing the water quality, including radioactivity, at a range of depths and establishing the hydraulic grade line;
- iv) Commission the STI abstraction and treatment works, and monitor their performance;
- v) Negotiate with Rand Water to conclude an off take agreement in terms of which they will receive and pay for the treated water at the treatment works or an alternative agreed location;
- vi) Invite proposals from the Private Sector to Design, Build, Operate and Maintain (DBOM), and possibly Design, Build, Operate, Maintain and Finance Public Private Partnership (DBOMF (PPP)), a solution with proven or bankable technology that can treat the neutralised water to the standard agreed with Rand Water under a contract for a period of 10 to 15 years' operation. Details of the supply point and delivery infrastructure to be defined;
- vii) Commission a Feasibility Study to investigate alternative abstraction points that can be used to reduce operating costs or maintain the required TOL in the event that abstraction at SWV Shaft proves to be problematic or unsatisfactory. The Study should include a reconnaissance phase review of all options and a Feasibility Study of the recommended alternative;
- viii) Commission a Feasibility Study to investigate underground disposal of waste products;
- ix) After 10 to 15 years, procure a new contract (DBOM or DBOMF (PPP)) for a 25-year period. A solution with the lowest whole-life costs, which may include or exclude all or any of the existing infrastructure, should be implemented. If found necessary, this could include or comprise abstracting from alternative locations identified in (vii); and
- x) After 25 years, procure a new contract. A technology provider to design, build and operate.

## **7. EASTERN BASIN: CONCEPT DEVELOPMENT AND TECHNICAL DUE DILIGENCE**

### **7.1 Introduction**

The identified preliminary Reference Project, described in Chapter 4, formed the basis for the work during the Concept Development part of the Study, during which the sizing, infrastructure component, layout and siting of all elements of the Reference Project, were developed in sufficient detail to prepare a Feasibility level cost estimate of the Reference Project.

Since the Reference Project is situated at Rand Uranium Shaft No. 8, where the abstraction and HDS treatment for the STI are planned, it is appropriate that those components form part of the Reference Project. These cost estimates are based on the CAPEX for the STI having been incurred and financed, and the plant being well operated until the Reference Project is commissioned. At that time, the operation and associated OPEX become part of the LTS.

### **7.2 The Short-Term Intervention**

In the Eastern Basin, the AMD abstraction pump station provided by the STI is located at Grootvlei Shaft No. 3, which has historically been used for this purpose by the mines.

Tenders have been invited for:

- The installation of “Long-Term” pumps at Grootvlei No. 3 Shaft, with an average capacity (19 hours per day) of 80 Mℓ/d, or maximum capacity of 101 Mℓ/d for pumping 24 hours per day to be commissioned before the TOL of 1 280 m amsl is reached in early 2014;
- An HDS neutralisation plant possibly with only limestone neutralisation at the abstraction point at Grootvlei No 3 shaft; and
- A 15.3 km long pipeline to transfer the sludge to the Ergo super-TSF for co-disposal.

### **7.3 The Reference Project**

#### **7.3.1 Abstraction Points**

In the Eastern Basin, Grootvlei No. 3 Shaft has been identified by TCTA as a possible pumping shaft, as it has been utilised in the past and proved to be sufficiently connected to the void. It draws directly from the shallower Kimberley Reef void and only indirectly from the deeper Nigel Reef void (due to a plug in the shaft). Due to its proximity to the dolomites in the area, lack of space for the required infrastructure and the fact that the ground level at the shaft is below the 1:100 year floodline, suitable alternatives were sought, and several were considered.

The STI proposes to raise the shaft collar above the floodline, and an extensive rock or earth platform to a level of 1 573 m amsl is proposed to raise the LTS works above the floodline.

This area is already highly impacted by past mining activities, and the environmental impacts of the fill platform will thus not be significant.

At present, elevated flows in the Blesbokspruit are impeded by a disused road bridge about 0.5 km downstream of Grootvlei No. 3 Shaft and a disused railway bridge about 0.4 km further downstream. In the floodline model, it has been assumed that both bridges will have been removed, and their demolition should be included in the construction contract for the STI.

After considering all the criteria, Grootvlei No. 3 Shaft was considered to be marginally superior to Marievale No. 5 Shaft and has been confirmed as the abstraction shaft for the STI. However, Marievale No. 5 Shaft could be a suitable alternative should the need arise.

### **7.3.2 Critical Levels and Target Operating Levels**

In the Eastern Basin, an ECL of 1 470 m amsl, about 100 m below the water table in the dolomitic aquifer, is expected to be low enough to protect the aquifer from pollution. A long-term freeboard of 20 m is proposed, giving a TOL of 1 450 m amsl. However, it is recommended that initially an ECL of 1 280 m amsl at the base of the dolomite be adopted, without the requirement for freeboard.

If adequate monitoring of the water quality in the dolomite has been established, and no pollution is observed at the ECL of 1 280 m amsl (associated TOL also 1 280 m amsl), the water level can be allowed to rise, possibly as high as 1 450 m amsl, provided that monitoring is carried out and AMD pollution is not detected. No SECL is currently set for the Eastern Basin.

### **7.3.3 Pumps and Pumping Rates**

It has been assumed that the pumps procured as part of the STI would be retained as part of the LTS, with a capacity of 80 Mℓ per 19-hour day. The selection of the treatment site is influenced by the position of the STI, in order to make use of as much of the STI infrastructure as possible.

The treatment site will be located at Grootvlei No. 3 Shaft, and it is assumed that infrastructure such as access roads and a power station will be provided as part of the STI. An alternative site is available at the Marievale Shaft No. 1 should there be any future problems with the Grootvlei No. 3 Shaft and/or site.

Balancing storage reservoirs will be provided between the abstraction point and the first stage treatment works, storing 24 hours of water production in two lined earth dams, each measuring 100 m by 80 m and 5 m deep.

An Ion Exchange plant will be incorporated between the balancing storage and the neutralisation plant, which will be provided as part of the STI.

The following site constraints exist for the Grootvlei site:

- The site lies within the 1:100 year floodline;
- A detailed floodline analysis must be carried out, and the treatment plant must be placed on raised rockfill platforms; and
- The provision of the rockfill platforms has been included in the costing.

### 7.3.4 Treatment Works

An Ion Exchange plant will be incorporated between the balancing storage and the neutralisation plant, which will be provided as part of the STI.

An RO desalination plant will be provided after the neutralisation plant with further balancing storage for treated water, storing 16 hours of water production in a concrete reservoir with two compartments, measuring 82 m in diameter and 10 m deep.

The main attributes of the site located at SWV Shaft are:

- The site will be located on the same site as the STI, which is currently under construction;
- The land is generally flat;
- Platforms can be constructed from material from commercial sources;
- Other essential services such as potable water and access roads will have been provided by the STI; and
- Balancing storage will be provided.

### 7.3.5 Residue Management

#### a. Sludge

The Reference Project for the LTS includes a SSF to manage both HDS and RO waste streams. This could be constructed on the land offered by Ergo at Withok or on one of the sites identified for the LTS (Study Report No. 5.5). These sites are on the east side of the Blesbokspruit, slightly south of Grootvlei No. 3 Shaft.

Based on the volume of HDS and RO sludge expected to be produced over 45 years, the predicted final size of the SSF is 938 m by 613 m by 14 m high.

The nature of the sludge is such that the solids do not settle and it remains gelatinous, making it unsuitable for constructing the perimeter wall of the SSF, and waste rock will thus need to be imported for this purpose.

It is assumed that the sludge will be classified as hazardous and that the SSF will be categorised as H:H in terms of DWA's "**Minimum Requirements for Waste Disposal by Landfill**" (DWA Third Edition, 2005 – Waste Management Series). This means that the site must be lined, and a leachate management system is required. Leachate and supernatant that do not evaporate must be pumped back to the treatment works and recycled.

A site selection process for the SSF was undertaken, as reported in Study Report No. 5.5. A suitable site has been identified. The site offers the following advantages:

- It is flat and gently sloping; and
- It is situated on open land.

The Concept Design for the pumps is based on pumping the combined sludge from RO and HDS.

The infrastructure for sludge disposal consists of:

- Sludge pumps; and
- Sludge pipeline.

Sludge from both the neutralisation plant and the desalination plant will be pumped to a new purpose-built SSF through a 5 km long 180 mm diameter HDPE pipeline. A 600 mm parallel HDPE return water pipe will be provided to return polluted rainwater falling on the SSF to the treatment works; it will be sized to accommodate a 200-year recurrence interval storm event.

#### **b. Brine**

It is recommended that the brine that will be produced should be disposed of in evaporation ponds, which are low tech and have low operating costs. Two ponds, each measuring 430 m by 300 m by 2 m deep, are proposed.

A suitable site for the ponds was identified, with the following attributes:

- The land slopes gently eastwards towards the Blesbokspruit.

### **7.3.6 Water User Locations and Infrastructure**

The concept design is based on delivering treated water to the basin boundary through a 10.6 km long, 1 300 mm diameter steel pipe.

The following observations on the pipeline were noted:

- The pipeline has to cross the Blesbokspruit, which could be via a pipe bridge; and
- Cathodic protection might be required. An investigation must be carried out to establish the ground conductivity.

### **7.3.7 Geotechnical Assessment**

The Desktop Study showed the following:

- The treatment site is underlain by the Vryheid Group; adjacent to it is the Dwyka tillite, dolomite and alluvium along the Blesbokspruit;
- While the founding is suitable, a detailed geophysical and geo-hydrological investigation will be required to determine the stability of founding grounds to carry water-bearing structures;
- The SSF site is underlain by rocks of the Vryheid formation and Dwyka Group; and

- The site of the evaporation ponds is underlain by rocks of the Vryheid Formation and Dwyka Group. The Dwyka Group consists mostly of tillite.

### 7.3.8 Environmental Assessment

The screening recorded the following:

#### a. Treatment Site

- A significant land use impact is not expected, due to the brownfields mine site location of the plant area;
- Irrigation pivots to the east of the Blesbokspruit all read as “ecological support areas” and “wetlands” according to GDARD’s CPlan;
- The risk of pollution of the Blesbokspruit due to the close proximity of the site is an environmental risk; and
- The land in question is not listed as environmentally sensitive in terms of GDARD’s CPlan, and there is evidence of degradation through mining land use and urban development in the surroundings.

#### b. Sludge Storage Facility

- GDARD’s CPlan indicates the entire area as “wetland”. The exact wetland area needs to be confirmed. Micro-adjustments will have to be made during the detail design of the SSF in order to optimise the placement. The potential loss of three disturbed pans will probably increase the environmental approval timeline of the current proposal;
- The proposed site is close to Aston Lake, and impacts on the lake and its associated ecological habitat can thus be expected and should be investigated further; and
- Best practice design standards with regard to liners and water management for the facility must be used to ensure the prevention of surface and shallow groundwater pollution.

#### c. Evaporation Ponds

- As evaporation will be the method of disposal, the inherent risk and expected environmental impacts are low;
- Further investigations must be conducted to ensure that wetland buffer zones and floodlines are excluded from development;
- Stormwater management issues will require specific attention in order to lower the environmental risks; and
- There is a high risk of pollution of the Blesbokspruit due to the close proximity of the site.

All of the above notes will require the necessary authorisations, such as the EIA, Water Use Licence Applications (WULA), etc.

### 7.3.9 Traffic Impact Assessment

The additional traffic in the area due to the establishment of the LTS will be negligible, as the roads used to accommodate traffic to the Grootvlei mine that has ceased to operate.

## 7.4 Conclusions

The recommendations for implementation in the Eastern Basin are summarised below. It should be noted that some of the recommendations are already being implemented:

- i) Monitor the implementation of the STI and the void water level to ascertain the lowest TOL at which it will be possible to prevent the water from rising further;
- ii) Invite proposals from the Private Sector to DBOM and (DBOMF) (PPP) a solution with proven or bankable technology that can treat the neutralised water to the standards required by Rand Water for a period of 10 to 15 years.  
Details of the supply points and delivery infrastructure to be defined;
- iii) During construction of the STI, review the current monitoring programme and recommend any required strengthening. The programme should include monitoring the water levels in the mine void at agreed locations across the , testing the water quality, including radioactivity, at a range of depths, and establishing the hydraulic grade line;
- iv) Commission the STI abstraction and treatment works and monitor the performance;
- v) Negotiate with Rand Water to conclude an off-take agreement under which they will receive and pay for the treated water at the treatment works or alternative agreed location;
- vi) Commission a Feasibility Study to investigate underground waste disposal;
- vii) After 10 to 15 years, invite new tenders for a DBOM or PPP, allowing bids for recently proven technologies with lower operating costs. It is possible that the incumbent contractor or another operator for the same plant will still be competitive because of existing infrastructure; and
- viii) After another 25 years, procure a new contract.



## 8. THE COSTS AND ECONOMIC ASSESSMENT OF THE LONG-TERM SOLUTION

### 8.1 Costs of the Reference Projects

The estimates of capital expenditure required for the LTS in each basin are based on the assumption that the capital cost of the Immediate Works and the STI, as planned by TCTA, are provided for elsewhere. The option of re-financing the cost of the STI in the same financial package used for the LTS has been raised, but is not allowed for.

The cost estimates for the Reference Projects for the LTS does include the following, related to the neutralisation works being provided in terms of the STI:

- The cost of the SSF to store both the HDS sludge and the desalination sludge, from the time of commissioning of the LTS; and
- The operating costs of the STI from the date of commissioning the LTS in each basin.

The cost of the projects recommended for medium-term implementation in the Western Basin (Pilot Treatment Plants) are expected to be less than the cost of the Reference Project, but the lifetime costs will be similar. In the Central and Eastern Basins, it is believed that the cost estimations for the Reference Projects provide a fair estimate of the cost of implementing the LTS.

The costs of the Reference Project for each basin are given in

**Table 8.1** and **Table 8.2** and include the following:

- The operating costs of the STI and LTS which comprise:
  - The annual operating costs for items such as staff, electricity, chemicals, routine maintenance, etc.
- The costs of scheduled major overhauls comprise:
  - Planned maintenance;
  - Overhauls; and
  - Replacement of equipment.

This expenditure is expected to occur at about 5 yearly intervals, with some expenditure on items only occurring every 10 or 15 years.

- The average annual O&M costs include all recurring expenditure.

The details of these costs are contained in Confidential Study Report No. 6.2.

The capital cost estimates in

**Table 8.1** are based on March 2012 prices.

**Table 8.1: Reference Project estimated Capital Costs**

	Western Basin		Central Basin		Eastern Basin	
	R million	% of CAPEX	R million	% of CAPEX	R million	% of CAPEX
<b>CAPITAL COSTS (CAPEX) – LTS</b>						
Civil Works (Site works, Balancing Storage, Land)	289	21	341	15	645	22
Treatment (Ion Exchange, Desalination)	438	31	708	31	1 148	39
Residues Management (Brine Disposal, Sludge Disposal and Return Water Management)	634	45	944	41	835	28
Treated Water Delivery	44	3	283	13	337	11
<b>Sub-total for LTS</b>	<b>1 410</b>	<b>100</b>	<b>2 280</b>	<b>100</b>	<b>2 970</b>	<b>100</b>
<b>Grand total for LTS</b>	<b>R6 660 million</b>					

**Table 8.2: Reference Project estimated Operating, Maintenance and combined Lifecycle costs for the STI and LTS**

Description	Western Basin		Central Basin		Eastern Basin	
	R million	% of OPEX	R million	% of OPEX	R million	% of OPEX
<b>OPERATING (OPEX) AND LIFECYCLE COSTS – STI and LTS</b>						
Electricity	36	21	40	15	54	17
Chemicals	59	35	122-	47	125	40
Sludge disposal	36	21	43	17	52	17
Brine disposal	4	2	9	3	9	3
General	35	21	46	18	70	23
<b>Sub-total</b>	<b>170</b>	<b>100</b>	<b>260</b>	<b>100</b>	<b>310</b>	<b>100</b>
<b>Scheduled major overhauls</b>	<b>60</b>		<b>70</b>		<b>120</b>	
<b>Average annual O&amp;M and Lifecycle costs</b>	<b>230</b>		<b>330</b>		<b>430</b>	

## 8.2 Economic Assessment

### 8.2.1 Introduction

An assessment of the economic benefits of implementing a LTS for AMD in the Western, Central and Eastern Basins was undertaken. The economic analysis assessed the macro-economic impact of implementing the LTS for AMD. The macro-economic impact assessment determined the effect of the construction and operation of the proposed LTS on the following economic variables, GDP, production, employment and income. The findings are presented in more detail in the Confidential Study Report No. 7. The costs presented in this report for the Reference Project in each basin were used as the input data to the economic model.

In this model, the direct expenditure, the indirect expenditure (expenditure in secondary activities to support and supply the projects) and induces expenditure (the expenditure on household goods and services by those deriving income from direct and indirect expenditure) were considered.

## 8.2.2 Quantitative Expenditure Impacts

### a. Quantitative Expenditure Impacts of the Western Basin

The direct investment in the domestic manufacturing and construction industry increase productivity in that sector and will cause increased productivity in other sectors of the economy. In total, the construction phase of the LTS for the Western Basin will raise the level of production by approximately R 2 749 million over three years. The operational phase will create a total increase in production of R 421 million annually. Expenditure during the lifecycles of the Western Basin will contribute R 7 362 million towards production in the study area. Raised production levels are accompanied by increased GDP. The direct impact of the construction phase is expected to be an increase of R 325 million in GDP. In total, the level of GDP will increase by approximately R 1 003 million due to construction. The operational phase will directly contribute R 47 million to the GDP on an annual basis, and the indirect and induced impacts will contribute a total of R 106 million.

The construction phase of the LTS for the Western Basin will require the employment of approximately 1 050 persons for a period of 3 years. Increased production in industries supplying the construction inputs, as well as consumer goods and services, implies the creation of new employment opportunities in these industries. The (indirect) impact on employment in supply industries will manifest in the creation of approximately 3 300 employment opportunities, whilst the impact on industries supplying consumer goods and services (*i.e.* the induced impact) will be the creation of approximately 3 210 employment opportunities. In total, the construction phase of the proposed plant will generate approximately 7 570 employment opportunities. The operational phase will create a total of 960 new employment opportunities on an annual basis. The new employment opportunities associated with the lifecycle phases will amount to 20 680.

### b. Quantitative Expenditure Impacts of the Central Basin

The direct investment in the domestic manufacturing and construction industry will cause increased productivity in other sectors of the economy. In total, the construction phase of the LTS for the Central Basin will raise the level of production by approximately R 3 995 million. The operational phase will create a total increase in production of R 532 million annually. Expenditure during the lifecycles of the Central Basin will contribute R 10 341 million towards production in the study area. Raised production levels are accompanied by increased GDP. The direct impact of the construction phase is expected to be an increase of R 493 million in GDP. In total, the level of GDP will increase by approximately R 1 471 million due to construction. The operational phase will directly contribute R 56 million to the GDP on an annual basis, and the indirect and induced impacts will contribute a total of R 133 million.

The construction phase of the LTS for the Central Basin will require the employment of approximately 1 590 persons for a period of 3 years. Increased production in industries supplying the construction inputs, as well as consumer goods and services, implies the creation of new employment opportunities in these industries. The (indirect) impact on employment in supply industries will manifest in the creation of approximately 4 340

employment opportunities, whilst the impact on industries supplying consumer goods and services (i.e. the induced impact) will be the creation of approximately 4 730 employment opportunities. In total, the construction phase of the proposed plant will generate approximately 10 660 employment opportunities. The operational phase will create a total of 1 200 new employment opportunities on an annual basis. The new employment opportunities associated with the lifecycle phases will amount to 29 040.

### **c. Quantitative Expenditure Impacts of the Eastern Basin**

The direct investment in the domestic manufacturing and construction industry will cause increased productivity in other sectors of the economy. In total, the construction phase of the LTS for the Eastern Basin will raise the level of production by approximately R 5 148 million. The operational phase will create a total increase in production of R 807 million annually. Expenditure during the lifecycles of the Eastern Basin will contribute R 17 211 million towards production in the study area. Raised production levels are accompanied by increased GDP. The direct impact of the construction phase is expected to be an increase of R 618 million in GDP. In total, the level of GDP will increase by approximately R 1 850 million due to construction. The operational phase will contribute R 85 million to the GDP on an annual basis, and the indirect and induced impacts will contribute a total of R 203 million.

The construction phase of the LTS for the Eastern Basin will require the employment of approximately 1 998 persons for a period of 3 years. Increased production in industries supplying the construction inputs, as well as consumer goods and services, implies the creation of new employment opportunities in these industries. The (indirect) impact on employment in supply industries will manifest in the creation of approximately 6 230 employment opportunities, whilst the impact on industries supplying consumer goods and services (i.e. the induced impact) will be the creation of approximately 5 960 employment opportunities. In total, the construction phase of the proposed plant will generate approximately 14 190 employment opportunities. The operational phase will create a total of 1 820 new employment opportunities on an annual basis. The new employment opportunities associated with the lifecycle phases will amount to 46 920.

## **8.2.3 Conclusions**

The implementation of the LTS for AMD and the required expenditure will have significant positive economic benefits for the region contributing a total of 16 677 million to the GDP (construction, operation, maintenance and equipment overhaul), creating more than 32 000 temporary and about 4 000 long-term employment opportunities.

## 9. LEGAL DUE DILIGENCE

### 9.1 Introduction

The purpose of the legal due diligence assessment is to identify any legal or regulatory issues that might negatively affect the project. It is important to establish legal certainty about the project by ensuring that all legal requirements are identified and addressed.

The legal due diligence assessment on the sites reviews the land ownership, land availability and any title deed endorsements or potential land claims on the identified land, as well as any lease interests. This chapter summarises the section on Legal Due Diligence in the Confidential Study Report 7.

The legislation that must be considered during implementation is shown in **Table 9.1**, and legislation of particular relevance is discussed in the following sections.

**Table 9.1: Legislation relevant to implementation**

Legislation	Possible relevance
National Water Act, 1998 (Act No. 36 of 1998) (NWA (36:1998)) -	Construction of Government Water Works (GWW), licensing requirements, and cost recovery.
National Environment Management Act, 1998 (Act No. 107 of 1998) (NEMA (107:1998))	Requirements for Environmental Impact Assessment (EIA).
Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA (28:2002))	Governs mining-related aspects relevant to the management of AMD.
Promotion of Administrative Justice Act, 2000 (Act No. 3 of 2000) (PAJA (3:2000))	Requirements for administrative processes, etc.
Constitution of the Republic of South Africa, 1996	Foundational principles guiding all legislative and procedural interpretation and actions.
Government Finance (such as Public Finance Management Act, 1999 (Act No. 1 of 1999) (PFMA (1:1999)) and Procurement-related Legislation	Financing and procurement.
Regulation 14 of the Regulations on Use of Water for Mining and Related Activities, GN 704, 1999	Procedures for and penalties.
National Environmental Management Act: Air Quality, 2004 (Act No. 39 of 2004) (NEMA 39:2004))	Regulating atmospheric emissions and related penalties.
National Environmental Management Act: Biodiversity, 2004 (Act No. 10 of 2004) (NEMA 10:2004))	Protecting biodiversity / indigenous biological resources.
National Environmental Management Act: Waste, 2008 (Act No. 59 of 2008) (NEMA 59:2008)	Waste management planning.
Mine Health and Safety Act, 1996 (Act No. 29 of 1996) (MHSA (29:1996))	If any activities in implementation can be construed to fall under the ambit of this act – for example, during co-disposal at a TSF.
Town planning and land use ordinances	Change of land-use and/or land-use conditions.
Disaster Management Act, 2002 (Act No. 57 of 2002) (DMA (57:2002))	If a 'state of disaster' may occur during implementation.

Legislation	Possible relevance
Deeds Registries Act, 1937 (Act No. 47 of 1937) (DRA (47:1937))	Land or land rights transfers.
Land Survey Act, 1997 (Act No. 8 of 1997) (LSA (8:1997))	Land surveying.
Companies Act, 2008 (Act No. 71 of 2008)	Dealing with specific companies and directors.
Government Immovable Asset Management Act, 2007 (Act No. 19 of 2007)	Review and asses identified sites.

## 9.2 Environmental Legislation

### 9.2.1 Introduction

Section 24 of the Constitution provides the following in respect to the environment:

**"24. Environment.** - *Everyone has the right:–*

- (a) *to an environment that is not harmful to their health or well-being; and*
- (b) *to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that:–*
  - (i) *prevent pollution and ecological degradation*
  - (ii) *promote conservation; and*
  - (iii) *secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development."*

Section 24 of the Constitution entrusts the State with the protection of the environment. Therefore, the State has a responsibility to the citizens to promote the spirit of the objectives of the Bill of Rights as envisaged in the Constitution. It can be said that section 24 imposes a duty on the State to promulgate legislation to protect the environment. It is clear that section 24(b), in particular, obliges the state to take legislative measures to protect the environment.

### 9.2.2 NEMA (107:1998)

In response to the provisions of the Constitution, the state has taken legislative measures to promote the spirit, purpose and objectives of the Bill of Rights. One of the foremost of these legislative measures is the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA 107:1998).

NEMA states that its purpose is to provide for cooperative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote cooperative environmental governance and procedures for coordinating environmental functions exercised by organs of state; and to provide for certain aspects of the administration and enforcement of other environmental management laws.

NEMA (107:1998) has been supplemented by various Government Notices, including:

**a. Government Notice No. 386**

This Government Notice identifies the following activities, which may not commence without environmental authorisation from the Competent Authority and in respect of which the investigation, assessment and communication of the potential impact of activities must be undertaken:

*"13 The abstraction of groundwater at a volume where any general authorisation issued in terms of the National Water Act, 1998 (Act No. 36 of 1998) will be exceeded."*

**b. Government Notice No. 387**

This Government Notice identifies the following activities, which may not commence without environmental authorisation from the Competent Authority and in respect of which the investigation, assessment and communication of the potential impact of activities must be undertaken:-

*"1 the construction of facilities or infrastructure, including associated structures or infrastructure, for:-*

- (e) any process or activity which requires a permit or license in terms of legislation governing the generation or release of emissions, pollution, effluent or waste and which is not identified in Government Notice No. R.386 of 2006;*
- (p) the treatment of effluent, wastewater or sewage with an annual throughput capacity of 15 000 cubic metres or more."*

**c. Government Notice No. 545**

This Government Notice identifies the following activities, which may not commence without environmental authorisation from the Competent Authority and in respect of which the investigation, assessment and communication of potential impact of activities must be undertaken:

*"10 the construction of facilities or infrastructure for the transfer of 50 000 cubic metres or more water per day, from and to or between any combination of the following:-*

- (i) water catchments,*
- (ii) water treatment works, or*
- (iii) impoundments,*

*excluding treatment works where water is to be treated for drinking purposes."*

### **9.2.3 NEM:WA (59:2008)**

The National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA (59:2008)) sets out to reform the law regulating waste management and deals with waste management and control in order to protect health and the environment.



Chapter 5 of NEM:WA (59:2008) deals with the issuing of waste management licences for waste management activities. Licence conditions are monitored and enforced to ensure environmental protection. The requirement for licensing applies to a range of listed waste management activities.

NEM:WA (59:2008) defines waste as:

*"any substance, whether or not that substance can be reduced, re-used, recycled and recovered:–*

- (a) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;*
- (b) which the generator has no further use of for the purposes of production;*
- (c) that must be treated or disposed of; or*
- (d) that is identified as a waste by the Minister by notice in the Gazette, and includes waste generated by the mining, medical or other sector, but:–*
  - (i) a by-product is not considered waste; and*
  - (ii) any portion of waste, once re-used, recycled and recovered, ceases to be waste."*

NEM:WA (59:2008) defines hazardous waste as:

*"any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment."*

Government Notice No. 718 identifies the following activities, which may not commence unless a licence is issued in respect of that activity:

*"3(11) the treatment of effluent, wastewater or sewage with an annual throughput capacity of more than 2 000 cubic metres but less than 15 000 cubic metres.*

*"4(5) the treatment of hazardous waste using any form of treatment regardless of the size or capacity of such a facility to treat such waste."*

The treatment of waste water is an activity that requires application for a licence. Waste needs to be classified before it can be treated or disposal of. Waste may only be disposed of in permitted facilities, and EIA authorisation is required for the establishment of disposal facilities.

## 9.3 Other Relevant Acts

### a. HSA (15:1973)

The object of the Hazardous Substances Act, 1973 (Act No. 15 of 1973) (HSA (15:1973)) is to provide for the control of substances that may cause injury, ill-health or death to humans. The Project needs to comply with the general principles and objectives of the HSA (15:1973).



**b. HRA (25:1999)**

In terms of section 38 of the Heritage Resources Act, 1999 (Act No. 25 of 1999) (HRA (25:1999)), any person who intends undertaking any development that will change the character of a site exceeding 5000 m<sup>2</sup> in extent must notify the responsible Heritage Resources Authority and furnish it with details regarding the location, nature and extent of the proposed development.

The activity intended by the Department is one of the activities listed in the HRA (25:1999) and NEMA (107:1998), respectively, and therefore the Department is required to notify the relevant authority of the activity in terms of the HRA (25:1999).

**c. GIAMA (19:2007)**

The Government Immovable Asset Management Act, 2007 (Act No. 19 of 2007) (GIAMA (19:2007)) defines “user” as a National or Provincial Department that uses or intends to use an immovable asset in support of its service delivery objectives and includes a custodian in relation to an immovable asset that it occupies or intends to occupy, represented by the Minister of such National Department, Premier of a Province, or Member of the Executive Council (MEC) of such Provincial Department, so designated by the Premier of that province.

In terms of section 4(5)(a) of GIAMA (19:2007), the Accounting Officer of the Department is the designated custodian in relation to the land for the duration of the Study, after which the custodian of the land shall revert to the Department of Public Works. The Accounting Officer as a custodian of the land is to act as caretaker in relation of the land.

## **9.4 DWA as the Implementing Authority**

### **9.4.1 Introduction**

The Department of Water Affairs – “The Department” (DWA) is the trustee of South Africa's water resources. It is primarily responsible for the formulation and implementation of policy governing the water sector. It also has overriding responsibility for water services provided by Local Government (LG).

The Department's mandate originates in section 24 and section 27 of the Constitution of the Republic of South Africa, 1996 and it is governed by the NWA (36:1998), which regulates and ensures that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that facilitate socio-economic growth, while protecting aquatic ecosystems and water users that depend on water resources.

The Department's main objective in undertaking the Study is to procure an AMD solution to prevent the uncontrolled decant of AMD water into water courses, and to ensure that AMD water is treated to acceptable standards; released or discharged into water courses fit for use; and distributed through a water conveyance systems.

The proposition, subject to the outcome of this Feasibility Study, is that the solution might be implemented on a traditionally procured employer design and procure, or a DBOM, or a DBOMF (PPP) basis.

#### **9.4.2 Competence of the Department to Undertake the Project**

The purpose of this section is to determine whether DWA has the competence to undertake the Project, by determining:

- the nature of the institutional function;
- whether the institutional function can be performed by the Private Sector party;
- the functionary constraints in respect of the competence of the Department; and
- the impact of the State Information Technology Agency Act, 1998 (Act No. 88 of 1998) (SITAA (88:1998)) and the Labour Relations Act, 1995 (Act No. 66 of 1995) (LRA (66:1995)) on the competence of the Department.

##### **a. Nature of the Institutional Function**

Everyone has the right of access to sufficient food and water.

In response to the provisions of the Constitution, the State has taken legislative measures to achieve the progressive realisation of the right of access to water resources. This legislative measure is the NWA (36:1998).

The institutional function of the Department (through the head of the Department) is to, inter alia, ensure that water is protected, used, developed and conserved, and to regulate the use, flow and control of all water in the Republic.

In light of the above, the procurement by DWA of a private party to undertake the project falls within the mandate of the Department.

##### **b. Performance of the Institutional Function by a Private Party**

The definition of an institutional function includes any part or component of or any service, task, assignment or other function performed or to be performed in support of such a service, task, assignment or other function. In light of the fact that the Department is to retain the provision of water resources, in our view, the procurement of a Private Sector partner (or partners) to design, construct, finance (in part or in full), maintain and operate the facility is an institutional function that can be performed in support of the other functions of the institution set out in the Constitution and NWA (36:1998).

The project falls within the definition of a DBOMF (PPP) (even if that form of contract is not used) and, as such, the private party can, in law, perform the institutional function (or a service in support of such function) on behalf of the Department.

### **c. The Functionary**

Regulation 16 of the Treasury Regulations defines an institution as a department, a constitutional institution, a public entity listed, or required to be listed in schedules 3A, 3B, 3C and 3D to the Public Finance Management Act, 1999 (Act No. 1 of 1999) (PFMA (1:1999)), or any subsidiary of any such public entity.

The Department is one of the national departments mentioned in the first column of schedule 1 of the Public Service Act, 1994 (Act, 103 of 1994) (PSA (103:1994)).

### **d. Institution**

It is plain that the Department is an institution as defined in Regulation 16 of the Treasury Regulations by virtue of being a national department mentioned in the first column of schedule 1 of the PSA (103:1994).

### **e. Impact of the LRA on the Competence of the Department**

Although the Department can procure a Private Sector party to perform its institutional function or a function in support of its institutional function, there are certain legal constraints/implications that may impact/limit the competence of the Department in undertaking certain aspects of the Project. The more apparent or likely of these constraints/implications, in relation to the Project, are listed below.

Section 197(2) of the LRA (66:1995) provides that if a transfer of a business takes place, unless otherwise agreed in terms of subsection 197(6) of the LRA (66:1995)), the new employer is automatically substituted in the place of the old employer in respect of all contracts of employment in existence immediately before the date of transfer, and all the rights and obligations between the old employer and an employee at the time of the transfer continue in force as if they had been rights and obligations between the new employer and the employee. Furthermore, to the extent that such transfer of the institutional function constitutes a going concern (or undertaking), then the Department must take cognisance of the provisions and implications of section 197 of the LRA (66:1995).

## **9.4.3 Site Enablement Issues**

The purpose of this section is to determine whether there are any limitations on the use of the identified sites for the purposes of the Study, where identified sites comprise (i) the land required for the treatment plant(s); (ii) the land required for pipelines to convey water to and from the water treatment plant(s); and (iii) the shafts from which the AMD water will be abstracted.

### **a. Description of the Properties**

There are a number of properties that are required for the treatment sites, pipeline routes, sludge storage facilities and brine disposal facilities in each of the three basins. The details of the sites for the different facilities are provided in Appendix A of the Confidential Study Report No. 7.

The identified properties span a number of erven, and a process of consolidation and/or subdivision will be required to package the land into useful parcels. The land is currently mostly zoned for agricultural use, but has minimal farming activities taking place. The process of securing, packaging and rezoning the land will have to be completed in principle prior to any construction taking place.

#### **b. Ownership of the Properties**

The various erven are owned by private owners, the Province of Gauteng, Transnet and the Municipality of Springs, and the owners of some of the erven are unknown. Access and rights to the properties will have to be secured either by purchasing the properties or transferring them to DWA. The details of ownership for each erf are contained in the table in Appendix A of the Confidential Study Report No. 7.

#### **c. Restrictions on the Use of Properties**

Most of the properties have registered servitudes and/or “Rights of Way” registered over them. The servitudes and rights of way will be adjusted or removed during the land acquisition phase of the project prior to the commencement of construction.

#### **d. Land Use Rights on the Properties**

The zoning on most of the properties is for agricultural use, although many of the erven have been used for the construction of infrastructure for mining operations. None of the land is heavily committed for agricultural purposes and is suitable for the intended use. Many of the erven are currently used for mining operations, and the construction of an AMD treatment plant or sludge/brine storage facilities would be a use similar to the present use of the land. The changing of the zoning would require an EIA, which in any case is planned. The details of the zoning on each of the erven are provided in the tables in Appendix A of the Confidential Study Report No. 7.

#### **e. Access to Private Property**

The NWA (36:1998) and the Water Services Act, 1997 (Act No. 108 of 1997) (WSA 108:1997) allow for authorised officers of DWA or a water management institution or its agent to have access on to privately owned land in order to carry out any water works required, although, inter alia, there are procedures that need to be adhered to. Private landowners cannot unreasonably refuse authorised officers or person's access or the granting of a servitude on their land, should the reason for the required access or servitude be necessary in terms of the law.

## 10. ALTERNATIVE INSTITUTIONAL PROCUREMENT AND FUNDING MODELS

### 10.1 Introduction

A key step in the Feasibility Process is determining the method to be used to procure the LTS. This section considers the method that will best balance the control of the project's whole life functionality, the project cost and project risk. It is based on the Procurement Options Analysis (POA) of the LTS for AMD, as described in the Confidential Study Report No. 7.

The purpose of the POA is to select the procurement methodology that best achieves the procurement objectives for the LTS. This includes the successful bidder taking over, maintaining and operating the infrastructure of the STI, once the LTS is commissioned. Thus, one entity will be responsible for all facilities from abstraction through treatment and residue management to delivery of treated water to the end-user.

Each of the options for procurement that were analysed comprised a combination of alternative procurement contracts, institutional responsibilities and source of funding. Each of these elements is discussed and then the options that were assessed are described.

### 10.2 Context

#### 10.2.1 Registered Project

The LTS for AMD is a project that was registered by National Treasury (NT) in terms of Regulation 16 of the Public Finance Management Act, 1999 (Act No. 1 of 1999) (PFMA (1:1999)), registered by NT in response to a request from the Director-General of the Department, dated 10 March 2012. The request to register the Project for a Long-Term Solution to Address the AMD Associated with the East, Central and West Rand underground mining basins registered was due to it being *“foreseen that the constitution of a Public Private Partnership (PPP) is likely to form part of the desired end-solution”*. The letter also requested the support of the PPP Unit of NT *“as we do not have the necessary expertise in our midst to ensure compliance with National Treasury requirements”*.

This POA forms part of Confidential Study Report No. 7 and is in support of the Department in meeting the requirement of Part 8 of the PPP manual in making a procurement choice.

#### 10.2.2 Approval to Proceed with Procurement

Regulation 16 of the PFMA (1:1999) sets out clear procurement steps that must be followed by the Department, and prescribes distinct treasury approvals that must be obtained.

The PAJA (3:2000) imposes a range of obligations arising from section 33(1) of the Constitution of the Republic of South Africa to effect citizen's rights to fair administrative action. These values are lawfulness, reasonableness and procedural fairness.

Each administrative action in a procurement process must be in accordance with the law and prescribed procedures; there must be accountability, responsiveness and openness in the decision-making of the Department; all bidders at each stage of a procurement process must have an equal chance of competing for the contract; and no action taken by Government may prejudice their competitiveness.

Regulation 16 of the PFMA (1:1999) sets out clear procurement steps that must be followed by the Department for a registered project and prescribes distinct treasury approvals that must be obtained.

Regulation 16.4.2 of the PFMA (1:1999) notes that “an Institution may not proceed with the procurement phase of a PPP without prior written approval of the relevant treasury for the feasibility study”.

Regulation 16.4.2 notes “The treasury approval referred to in regulation 16.4.2 shall be regarded as Treasury Approval 1”.

In compliance with the PFMA Regulations, this Feasibility Study will have to be submitted to NT as the ‘relevant treasury’ for approval prior to the procurement phase commencing, within a DBOMF (PPP) or Public Sector Comparator (PSC).

### **10.2.3 Criteria for Procuring an LTS**

The LTS for managing the AMD involves not only the provision of infrastructure and an appropriate technology, but also the O&M of that infrastructure. In assessing the options for procurement of the LTS, the least cost sustainable solution for AMD over the life of the LTS that has acceptable risk for Government – this should result in:

- A pumping solution that is sufficiently flexible to allow for changes to be made to the TOL and the volume pumped due to changes in the ingress;
- The treatment of AMD extracted from the mining void so that the resulting treated water does not negatively impact the environment, but becomes a water resource for the Vaal River System;
- A treatment solution that is sufficiently flexible to respond to varying water quality pumped from the void and short, as well as long-term variations in quantities which are pumped to maintain the water level at or below the TOL; and
- A waste disposal solution for the sludge from neutralization and residues (mainly sludge and brine) from the desalination process that is sustainable over the long-term and that is managed so that the environment is not negatively impacted.

The key aspect impacting the design of the LTS is that the solution provided will be focused on delivering an operating solution for many decades – realistically over a century. The primary criterion, which has to be considered, is a sustainable LTS that has the minimum whole life cost, which will be driven by the cost of operation and maintenance.

## 10.2.4 The Reference Project

The Reference Project is the solution conceptualised and costed that is capable of treating AMD to the required output quality in a sustainable manner. The capital, operating and lifecycle (major maintenance, refurbishment and replacement) costs of the Reference Project have been estimated for the selected technical solution and used as the basis for assessing the procurement options.

## 10.3 Options for Procurement Contracts for the LTS

A number of procurement options are available as shown in **Table 10.1** and discussed in the Confidential Study Report No. 7.

**Table 10.1: Contracting structures**

Item	Contracting Structure	Description
1	Employer Design, Procure, Construct and Operate. (The traditional structure)	Government procures a design team to design; Government contracts a constructor and a technology supplier individually; Government operates and maintains the technology and infrastructure directly or through operating contracts.
2	Design Build (Turnkey)	Government procures a design and construct contractor to design the infrastructure and technology solution; provide the technology plant and equipment; construct the infrastructure and hand the completed works over to Government. Government operates and maintains the technology and infrastructure directly or through operating contracts.
3	Concession	Lease of an asset of Government to a Private Party for a long period of time where the risk of funding, developing, managing and operating the asset is transferred to the Private Party.
4	Lease, Develop and Operate	Lease, develop and operate where a Private Party is given a long-term lease on the STI to operate and expand existing infrastructure, and the Private Party is to invest in the operation and expansion of the infrastructure to become the LTS and recover the cost of the investment over the duration of the lease.
5	Build, Own and Maintain	Build, own and maintain is where the Private Party is to build; own and maintain infrastructure (such as a school or clinic), and the Government is to lease that infrastructure from the Private Party and operate the infrastructure itself.
6	Build, Own, Operate and Transfer (BOOT)	Build, own, operate and transfer is where a Private Party finances, builds, owns and operates infrastructure for a specified period and hands the infrastructure over to Government on expiry of the contract. ( <i>Private Party owns the assets, but transfers them on contract expiry</i> ).
7	Design, (Build) Operate, Train and Transfer (BOTT)	Design, (build,) operate, train and transfer is where a Government finances and the Private Party; builds, operates the infrastructure for a specified period trains operators and hands the infrastructure over to Government on expiry of the contract with staff who are trained in its operation.
8	Build Own and Operate (BOO)	Build own and operate is where the Private Party owns the project in perpetuity. (Private Party owns the assets, and never transfers the assets to Government).
9	Design, Build, Operate, Maintain and Finance (DBOMF) (PPP)	Design, build, operate, maintain and finance is where Government contracts a Private Party solution provider to fund and design the solution; provide the technology solution, including plant and equipment; construct the infrastructure and operate and maintain the technology and infrastructure for a determined contract period, handing all assets back to Government on expiry of the contract in a fully functional and operating condition to determined standards.



Item	Contracting Structure	Description
10	Design, Build, Operate and Maintain (DBOM)	Design, build, operate and maintain is where Government funds the works and contracts a solution provider (generally from the Private Sector, but possibly a Public Entity) to design the solution; provide the technology solution, including plant and equipment; construct the infrastructure and operate and maintain the technology and infrastructure for a determined contract period, handing all assets back to Government on expiry of the contract in a fully functional and operating condition to determined standards.

The required output of the LTS treatment process is treated water to the required standard and management of sludge and brine residue in a sustainable manner over the long term, at a minimum whole life cost. Unlike many water infrastructure development projects, it is the operational stage of this project that will dominate the sustainability assessment and cost analysis and thus the procurement model selection analysis. The key success factor to achieve this would be securing or procuring an operator who would then select the technology and design the infrastructure to support the technology. The operator will also procure the construction contractor to optimise the operating efficiency in the long term.

Given these requirements consideration of risk, and other requirements, it was clear that either a DBOM (No. 10 in **Table 10.1**) or a DBOM with finance, i.e. a DBOMF (PPP) (No. 9 in **Table 10.1**) contract would be the most suitable. In addition, the traditional structure of an Employer Design, Procure, Construct and Operate (No. 1 in **Table 10.1**) was used as a base case for comparison.

## 10.4 Institutional Options for Managing the LTS

The Government sees the long-term role of the Department as being the water sector policy maker and regulator, and the trustee of South Africa's water resources. While the Department currently has extensive operational commitments, it is primarily responsible for the formulation and implementation of policy governing this sector. The Department as the accountable Institution has the responsibility to secure on behalf of the State and effective and sustainable LTS to AMD. The various institutional arrangements for procuring and managing the LTS are discussed below.

It has been proposed that Government should establish an Agency to be responsible for major water infrastructure development and operation. This has not yet been established and the Department, often assisted by TCTA, is fulfilling this role.

While the Department would contract with the selected Special Purpose Vehicle (SPV), the contract could be managed using:

- In-house resources; or
- Contracting a Public Entity as the managing agent.

In any of the scenarios, the Department would be the responsible party representing Government, but would operationalize the management of the contract using one of the



above options. In this way, the Department would achieve the most cost-efficient funding and retain the choice of the management structure.

The institutional options available for the Department to procure and manage the development and operational phases are to:

- Manage the project directly, using:
  - Resources from within the Department supported by a Professional Service Provider (PSP);
  - Delegating responsibility, through a suitable contract to a managing agent sourced either from a Public Entity or from the Private Sector; or
- Appoint a Public Entity as the Implementing Agent (IA) which would contract with the Service Provider directly on behalf of the Department. The IA performs an institutional function (pumping AMD to secure the applicable water control level and treating AMD to the required quality) on behalf of the DWA and delivering the treated water to an agreed point.

In any of these scenarios, the Department would retain accountability and ownership of the water and control of the process and outputs.

## **10.5 Funding Options**

### **10.5.1 Introduction**

There are fundamentally two sources of funding; the Revenue Fund or loans from the Private Sector. A mix of these can provide a number of funding models. The sources of funding are:

- Government from the Revenue Fund;
- Private Sector or International Funding Agencies directly to Government;
- Private Sector funding via loans to a Public Entity (State-Owned Entity (SOE)) or a Water Board), with an implicit or explicit Government guarantee; or
- Private Sector funding to a Private Sector SPV or Service Provider, established to implement a DBOMF (PPP) project.

Where public funds or Sector loans to a Government or a Public Entity are used, the Implementer (the Department or an IA) will pay the Service Provider against agreed deliverables. Where commercial loan funding is sourced by a SPV, then the funding will flow directly from the commercial banks to the SPV. The Implementer will then pay the SPV against agreed deliverables.

### **10.5.2 Public Sector Funding**

Funding from Government from the Revenue Fund usually requires that provision is made in the Medium-Term Expenditure Framework (MTEF) budget for the required capital. The Department has funding allocated annually for capital works and the funding, which has been allocated, is advised to the Department, with any associated conditions.

Capital funding provided through the annual budget has to be spent in the year in which it is allocated. While conditions attached to the funding can be stipulated, the procurement method is usually not a consideration. Funding from the annual budget, where the Department is the Implementer with an IA, if utilised, does not result in substantial transfer of financial risk which is retained by Government.

In addition to the repayment of capital and payment of interest on the outstanding amount, there is a considerable funding requirement for the operating, maintenance and lifecycle costs of the STI and LTS infrastructure and treatment management and operations. The costs will only partially be funded from the revenue secured from the sale of treated water and saleable waste products produced, since the revenue will not meet the “operating” costs and that there will be a shortfall. The State will have to meet this shortfall, and this liability will exist for as long as the problem persists.

### **10.5.3 Private Sector Funding**

The principal approach is that Government will have to ensure that the funding required for implementation is available and then recover the cost from various parties as timeously and effectively as possible.

If the Department uses an Implementer or procures a DBOMF (PPP) contract and irrespective of the sources of funding, it is envisaged that DWA will be paying the Implementer or the Special Purpose Vehicle (SPV), a Unitary fee (R/m<sup>3</sup>) to enable them to repay their loans and to cover their operating costs.

#### **i) Public Entity IA as borrower:**

A Public Entity appointed as IA can secure private funding to meet the capital and operating requirements. The funding could be against the balance sheet of the entity, project funding with explicit guarantees from the State or project funding with implicit contingent guarantees. Government would provide the Implementer with a guaranteed income stream such as a payment per cubic metre of water pumped and treated (a Unitary fee) which could be from the VRT Waste Discharge Charge System (WDCS) or other source. Government would thus be providing an implicit or explicit guarantee. The funding will be at “attractive” commercial rates and probably at a lower rate than that at which a Private Sector Borrower can secure loan funding. A value for money test would usually show that capital funding sourced through NT is cheaper than commercially raised loans.

#### **ii) DBOMF (PPP) with Private Sector as borrower:**

In this model Private Sector “non-recourse project finance”, with the Private Sector shareholders to the SPV investing equity and a commercial bank lending project finance to the SPV would be used. It does not directly impact the Government balance sheet. The loan is assessed against the credit-worthiness of the contracting institution and the security of the revenue flow for the duration of the project. The contract would commit Government to make an agreed payment per cubic metre of water (Unitary fee) delivered to specifications.

Where Private Sector “non-recourse project finance” funding is used, it would be financially inefficient for the Department to direct a Public Entity to act as an IA on its behalf. It has been established in informal discussions with Private Sector commercial Lenders, that should such a model be contemplated (where an IA contracted a Private Sector SPV, and the SPV secured all or a part of the funding on behalf of the Department), that the funding institutions would probably add a risk premium to the cost of funding. To avoid that situation, the cheapest way of using project finance to fund the capital requirement is for the Department to contract directly with an SPV company, which then secures capital funding from the commercial banks. A Public Entity could be the Managing Agent.

Where a Public Entity is the IA, acting on behalf of Government, they can obtain commercial loans from the Private Sector.

iii) Combination of funding sources:

A combination of Private Sector finance, and a Government capital contribution, is a variation that has been used on other projects to reduce the unitary fee, while maintaining the rigour brought to the project by commercial Lenders. The use of Government capital as a contribution to the project would normally be limited to 50% of the loan or approximately 40 to 45% of the capital required.

Either of the Private Sector funding options can therefore be a model with 100% Private Sector funding or a model where Government makes a substantial, although minority funding contribution.

iv) Funding operating costs:

In structuring the contracts, DBOM or DBOMF (PPP), the service providers will require certainty of revenue for all treated water that meets or exceeds the specification to fund their operating costs and for the DBOMF (PPP) to repay their loans. The Financial models, which have been used for the Value Assessment described in Chapter 11, have been structured that the Department (or IA) will pay on a monthly basis an agreed amount based on the volume of treated water. In the contract there will be safeguards for the service provider so that if the volume required to be pumped reduces that they will recover their fixed operating costs, which would include the interest and capital redemption costs. The contract will also incentivize the operator to minimize its variable operating costs so that the monthly exposure of the State is minimized.

## **10.6 The Procurement Institutional and Funding Models**

### **10.6.1 Introduction**

The following three procurement, institutional and funding models were considered in detail, each of which has a different risk profile for the Department and requires differing levels of project and operational management by the Department. Given the importance of the operational stage each of the models includes a discussion on the impact of the operational

stage in the analysis.

Three models have been defined for use in the Value Assessment and each is described in the following sections.

### **10.6.2 Employer Design, Procure, Construct and (the Public Sector Comparator) Operates**

In the PSC model, the Public Sector (the State), is the solution provider and will fund, design, procure the infrastructure and technology, and then operate and maintain the facilities to meet the required quality and sustainability specifications. This would be done through a number of individual contracts placed and managed independently. The State might choose to implement directly, using resources from the Department.

Financing, design, construction, technology selection and supply and operational risk will remain with the State.

### **10.6.3 Design, Build/Construct, Operate and Maintain (DBOM):**

In the model which has been considered, the Department would direct a Public Entity to be the IA and contract Private Party. It is thus subsequently referred to as DBOM (IA). The IA would also secure Private Sector loan funding for the project.

In this model, the IA procures the services of a Private Party, in terms of which the Private Party contracts to deliver treated water from abstracted from the void, and manage all the residues.

The Private Party will operate the infrastructure and technology equipment that it has installed and connected to the infrastructure provided by the STI and operates and maintains that STI infrastructure for the contract duration.

### **10.6.4 Design, Build/Construct, Operate, Maintain and Finance (DBOMF):**

The DBOMF (PPP) contract is a long-term contract between the Public and Private Sector. The main objective of DBOMF (PPP) all over the world is to ensure the delivery of well-maintained, cost-effective public infrastructure or services. The Private Sector puts its own equity capital at risk; funding its investment in the project with debt and shareholder equity. The difference between the PSC, either traditionally procured or procured through an IA, using a DBOM contract and DBOMF (PPP), is that the Private Party uses the project's assets and/or future revenues as the basis for raising funds.

The envisaged project structure is for a SPV that is to be project financed, rather than corporate financed.

It is thus assumed that the Private Party will use Project Finance, with limited recourse, to fund the project. The sources of funding for the project and how the funds will be used are detailed in the Confidential Study Report No. 7.

While it has been advised that for financial efficiency, the DBOMF (PPP) contract should be between the Department and the SPV; the Department could manage the contract, using either departmental resources or a Public Entity or a PSP as a managing agent.

## **10.7 Financial Control and Reporting**

The Department has a number of reporting requirements that have to be complied with, primarily the NWA (36:1998), PFMA (1:1999), and GIAMA (19:2007). The Department will have to report annually on the assets involved and budget for their operation, maintenance, refurbishment and replacement in the MTEF.

If Private Sector funding is involved, the Lenders will appoint a Lender's Technical Advisor (LTA) who will be responsible for reviewing the major maintenance performance and major maintenance plan of the service provider.

On the assumption that NT may at least initially be making an annual operational contribution to the project to cover the shortfall between the revenue collected for the sale of the treated water and the cost of treatment and repayment of capital funding, NT will require, as part of the annual budgeting process, to understand the expenditure forecasts for the upcoming MTEF period and for the remainder of the contract and possibly even for a determined period thereafter.

The Project will have to provide for and meet budget requirement for payment of the milestone payments during construction or the agreed escalated unitary fee less the revenue forecast to be received for the treated water. The revenue for the treated water will be collected by the Department in the Trading Account from the recipients of the treated water and ring fenced for use to part fund the unitary fee. The Unitary fee will escalate at Consumer Price Index (CPI) for the duration of the contract.

## **10.8 Conclusions**

The preferred contracting model will be one where the operations, supply and installation of technology, design, construction and maintenance are integrated and provided by a single entity with minimum risk to Government for the minimum cost for the duration of the contract in a sustainable manner and with an enduring positive legacy.

The identified model that meets the objectives is a DBOM model with the contract being agreed with a single Service Provider, or a DBOMF (PPP) with the private sector providing some or all of the funding.



## **11. ASSESSMENT OF PROCUREMENT, INSTITUTIONAL AND FUNDING MODELS**

### **11.1 Introduction**

This section assesses the procurement options, primarily based on the outcomes of the Value for Money Assessment. The objective of the process is to identify which of the short listed procurement option that provides the best Value for Money to the State on a risk adjusted basis. The procurement options considered were a PSC model where the State carries out all the functions and assume most of the project risks, a Design, Build, Operate and Maintain model, implemented by an Implementing Agent, (DBOM) (IA), in which the IA secures the funding and a DBOMF (PPP) model.

### **11.2 Basis for Value Assessment**

#### **11.2.1 Introduction**

The value assessment stage of the Feasibility Study assessed the selected procurement options which the Department (the Institution) could use and indicated how they differ in terms of affordability, risk transfer and value for money. For the LTS, the Department has the option of doing the design and construction, and providing ancillary services itself or using the services of an Implementing Agent (IA) (such as TCTA or Rand Water) and lastly, using a Private Party to provide all the services required. The choice of whether to procure the solution through a traditional PSC, a DBOM or a DBOMF (PPP) can only be made after this Value Assessment.

The Value Assessment subjects the project to the following three strict tests in terms of NT requirements and industry practice:

- Affordability;
- Risk transfer; and
- Value for money.

Affordability is discussed below while the risk transfer and value for money, which are interlined, are discussed in the next section.

#### **11.2.2 Affordability**

Affordability relates to whether the cost of the project over the whole project life can be accommodated in the budget of the Department given its existing commitments.

It is understood that the budget from the MTEF shows that the budget allocation for AMD is R 150 million for the 2013/14 MTEF year with the condition that the money is allocated subject to a revenue plan or bankable project with both TCTA and Rand Water as joint IAs. In this report, it is assumed that the R 150 million is for all the Witwatersrand basins, and for

the purposes of this analysis, the budget will be divided evenly among the three basins. The reason for this is that the Department might want to do separate procurement for each of the three basins.

If this is the only budget for AMD in the MTEF, then it is not affordable in terms of the NT definition.

### 11.2.3 Key Assumptions

#### a. Inflation Rate

The inflation forecast has been set at 5.5%, which is within the South African Reserve Bank target range of between 3 and 6%. Construction costs are escalated at the rate forecast by the Bureau for Economic Research (BER).

#### b. Taxation

The provisions of the Income Tax Act (Act No. 58 of 1962) and the Value-Added Tax Act (Act No. 89 of 1991) (VAT 89:1991) have been used in constructing the tax implications of the transactions in order to determine the tax cash flows.

#### c. Currency Treatment

It is estimated that about 52% of the capital cost will be imported. The imported content is usually under agency agreement to local suppliers, but the prices are subject to variation due to exchange rate fluctuations. It is assumed that the exchange rate used will be in US dollars. As at 31 May 2013, the Rand/US Dollar exchange rate was R 9.00 and that rate was used.

#### d. Financial Assumptions

The discount rate has been benchmarked against a Government Bond yield rate over a term similar to the length of the project term. The discount rate that has been used to discount the project cash flows is 4.40% real and 10.53% nominal. A risk margin of 3% has been added to both the rates.

#### e. Project Timing

A cash flow analysis of all costs in the project was done, and a record kept of the costs used and the assumed duration of the project. The model base date is 31 March 2012; it was assumed that construction will start on 1 April 2015; and full operation of Reference Project in the basins will be on 1 January 2017. In the financial model, all the 2012 costs are escalated to match these assumed project timing.

#### f. Capital Costs

The capital cost estimates for the Reference Project, shown in **Table 11.1** are based on March 2012 prices. They were also provided in **Table 8.1**, but are repeated here for convenience.



**Table 11.1: Reference Project's estimated Capital costs**

Description	Western Basin		Central Basin		Eastern Basin	
	R Million	% of CAPEX	R Million	% of CAPEX	R Million	% of CAPEX
<b>CAPITAL COSTS (CAPEX) – LTS</b>						
Civil Works (Site works, Balancing Storage, Land)	289	21	341	15	645	22
Treatment (Ion Exchange, Desalination)	438	31	708	31	1 148	39
Residues Management (Brine Disposal, Sludge Disposal and Return Water Management)	634	45	944	42	835	28
Treated Water Delivery	44	3	283	12	337	11
<b>Sub-Total for LTS</b>	<b>1 410</b>	<b>100</b>	<b>2 280</b>	<b>100</b>	<b>2 970</b>	<b>100</b>
<b>Grand Total for LTS</b>	<b>R 6 660 million</b>					

**g. Operating Costs**

The operating cost estimates for the Reference Project and the combined lifecycle costs for the LTS and STI are shown in **Table 8.2** and repeated in **Table 11.2** for convenience.

**Table 11.2: Reference Project's estimated Operating and combined lifecycle costs for the STI and LTS**

Description	Western Basin		Central Basin		Eastern Basin	
	R million	% of OPEX	R million	% of OPEX	R million	% of OPEX
<b>OPERATING (OPEX) AND LIFECYCLE COSTS– STI and LTS</b>						
Electricity	36	21	40	15	54	17
Chemicals	59	35	122	47	125	40
Sludge disposal	36	21	43	17	52	17
Brine disposal	4	2	9	3	9	3
General	35	21	46	18	70	23
<b>Sub-total</b>	<b>170</b>	<b>100</b>	<b>260</b>	<b>100</b>	<b>310</b>	<b>100</b>
<b>Scheduled major overhauls</b>	<b>60</b>		<b>70</b>		<b>120</b>	
<b>Average annual O&amp;M and Lifecycle costs</b>	<b>230</b>		<b>330</b>		<b>430</b>	

In the financial model, all the 2012 costs are escalated in the financial model to match the current dates these assumed project timing.

**h. Revenue**

It is expected that treated water will be “sold” to a recipient. The selling price will take into account that the water will be equivalent to treated Vaal River water treated to potable or higher industrial standard and delivered in the Witwatersrand and the value includes the cost of delivery and treatment to the elevated level. It is anticipated that the revenue stream from the sale of treated water will accrue to the Department, and it has thus not been included in the models.

No revenue assumptions have been made for residue products such as gypsum. However, it is assumed that when the procurement documentation is drafted and later negotiated with

a Preferred Bidder, the benefits from the sale of residue products will be for the benefit of the contractor; no income has been allowed in the model. The nature and cost of the required residue management measures will also be the responsibility of the contractor.

## **11.3 Risk Assessment**

### **11.3.1 Risks Transfer in the Alternative Models**

Risk is inherent in all options; a process that allows for the identification, mitigation, quantification and allocation of risks is thus essential. The differences between the risk transfers in the three options for implementation are as follows:

#### **a. Conventional Public Sector Procurement**

In this PSC model, the Government funds the capital and pays for operating costs. The Government Institution prepares detailed specifications that describe the infrastructure required to deliver a service. The required infrastructure is then put out to tender to get the expertise and experience of a private company for the design of infrastructure, which is then tendered by the Institution to procure a contractor to complete the construction of the infrastructure design. The Institution is responsible for the planning and design of the project, all statutory requirements (such as environmental and heritage approvals and town planning requirements) and any costs that may arise due to unforeseen circumstances during construction or elements that were omitted from the design or the tender. The contractor is only responsible for what is covered by the tender specifications and contained in the Bill of Quantities (BoQ), or anything that could reasonably have been foreseen. The Institution then operates the infrastructure.

Risk is held by the Institution responsible for funding, designing, constructing and operating the infrastructure. The Institution has to establish and have in place competent and capable staff to manage the integration and delivery of functional infrastructure, on time, and within budget and then operate the infrastructure. History shows that this is usually not successfully achieved.

#### **b. Design, Build, Operate and Maintain with Implementing Agency**

In this model (DBOM (IA)), a Public Entity, as defined in the PFMA (1:1999), is mandated by Government to implement a DBOM integrated solution with funding secured by the IA.

The risk that this DBOM (IA) solution effectively allocates to a contracting entity is the design, construction, operational and maintenance risks. The contractor will draw up a budget for the costs specifically associated with providing the services and infrastructure to deal with the AMD problem. In addition, the IA will charge a management fee for the construction and operating period. However, the funding risk is not transferred, and the equity holder is Government. The IA has a professional role and responsibility to deliver a sustainable solution and manage performance in compliance with the required specifications, but does not have a shareholder's interest in ensuring the outcome. It will be incumbent on the IA to establish project monitoring capability with the role of monitoring the project on behalf of the

funder (those providing the loans) and the shareholder (Government). This capability will take on the role usually undertaken by commercial Lenders in a DBOMF (PPP) project.

### **c. Design, Build, Operate, Maintain and Finance (DBOMF) Public Private Partnership (PPP)**

The Private Sector puts its own equity capital at risk; funding its investment in the project with debt and shareholder equity.

Securing private sector funding for the project through a Private Party SPV means that the Private Sector funders take on project risk for the loan. This risk transferred to the commercial banks results in the banks taking a keen interest in the performance of the service provider. The Lender will, with its appointed advisors, review the technology selected for long term sustainability, the suitability and functionality of the design solution, progress and the quality of the work performed in delivering the works and the commissioning process. The Lender will advance payment to the SPV and thus, the constructor, designers and technology supplier on work completed. During the operating phase, the Lender will monitor the performance of the service provider to secure the revenue stream to the private party and thus, its ability to repay the outstanding loan. The Lender will also monitor the maintenance performed and the planned programme of maintenance and refurbishment to contract expiry.

The majority of the technical and financial risk is transferred to the Private Sector and a small amount will be retained by the Department. The funding agencies will exercise technical (and financial) oversight of all phases of the project to protect their investment, thus reducing the risk to Government.

### **11.3.2 Risk Analysis**

The purpose of the risk analysis is a cornerstone concept in order to achieve value for money. The risk matrix is a tool that is used to identify and quantify the risks related to the project and to allocate the identified risks to either the Implementer (Government or IA) or the Contractor (Private Sector).

The risk analysis is two-pronged, involving risk identification and quantification and then allocation.

The risk matrix prepared for the project will be used by both the Legal Advisor and the Financial Advisor during procurement. The Legal Advisor will use the risk matrix, specifically the risk allocations, as the basis for preparing a draft DBOM or DBOMF (PPP) agreement that achieves the transfer of risks identified in the project in accordance with the risk allocations. The risk matrix will also be used by the Financial Advisor for a DBOMF (PPP) contract in evaluating the bids, and will therefore also define the broad parameters of the negotiations.

The risks for all options are assessed in terms of:

- Likelihood (Probability) – how likely is the risk to occur?; and
- Impact (Effect on Variable) – what would the impact be if it did occur?

These two scores are then combined (likelihood x impact) to provide an overall risk score.

This risk score can then be plotted on the risk matrix. The risk matrix indicates the overall risk category (low, medium, high) for each risk, as well as the how that risk should be managed.

In developing the risk matrix, the project team took into account that project risk changes depending on the Project Phase. The different phases of project would be:

- Development Phase;
- Delivery Phase; and
- Exit Phase.

The risk allocation indicates who has ownership of the risk item, or if the risk is shared between the Implementer and contractor and in what proportion. The value of the risk is then quantified as:

$$\text{Value of Risk} = \text{Cost Impacted} \times \text{Probability} \times \text{Impact/Effect on Variable}$$

The main risk categories are:

- Planning;
- STI;
- Underground mine water hydrogeology;
- Construction works;
- Environmental;
- Operations;
- Legal;
- Financial and economic; and
- Broad-Based Black Economic Empowerment (B-BBEE).

### 11.3.3 Assessment of Value for Money

Treasury Regulation 16.1 defines value for money as: “if the provision of the institutional function or the use of state property by a private party in terms of the DBOMF (PPP) agreement results in a net benefit to the institution, defined in terms of cost, price, quality, quantity, or risk transfer, or a combination thereof”.

The Value for Money test is performed by comparing the DBOMF (PPP) bidders' financial bids against the risk-adjusted PSC Financial Model, after adjusting the PSC model for the comparable allocation of the risks identified in the risk matrix. In this Study, as an indication of the value for money, the risk-adjusted PSC financial model is compared to the DBOMF (PPP) reference model. The PSC is also compared to the DBOM (IA) model, using the NPV of the IA as the indicator.

When analysing all the options, value for money for a project is obtained if the net cost of the private party or IA with DBOM is less than the risk-adjusted cost of government undertaking the project itself. In order to allow a comparison of all options, the Net Present Values of all options are calculated by discounting all the cash flows of the available option. A real discount rate of 4.40% and a nominal discount rate of 10.53% are used.

In the DBOM model, a level of risk is transferred to the service provider. The IA remains responsible for:

- establishing procurement criteria and specifications;
- procurement;
- monitoring the construction activities;
- authorising payment for milestones achieved;
- monitoring the performance of the service provider to deliver;
- monitoring the quality of the treated water produced;
- perform the maintenance and asset preservation; and
- approving payment for treated water to specification for the duration of the contract.

#### **a. Public Sector Comparator**

The PSC model estimates risk adjusted costs if the project were to be financed, owned and implemented by the Department. The assumption is that the Department will either use existing surplus funds in the Fiscus, or NT will issue debt (Government Bonds) to be repaid over a specific period to fund the project. The assumption is that there are no costs to the project for the provision of funding.

The risk adjustment was the result of a detailed analysis of all the risks affecting the project. The escalated base cost at April 2015 and risk-adjusted capital and operating costs are given in **Table 11.3**.

**Table 11.3: Risk-adjusted capital and operating costs (PSC)**

Cost Component	Western Basin	Central Basin	Eastern Basin
	million	million	million
<b>Capital Costs</b>			
Escalated Base Capital Cost including VAT (Excluding Risk)	1 960	3 124	3 915
Risk Adjustment	317	505	633
<b>Risk-Adjusted capital cost</b>	<b>2 277</b>	<b>3 630</b>	<b>4 548</b>
<b>Operations Costs</b>			
Escalated Average annual OPEX including VAT (Excluding Risk)	279	350	386
Average annual real risk adjustment	88	115	129
<b>Average annual real risk-adjusted operations cost</b>	<b>366</b>	<b>465</b>	<b>515</b>

### b. Design, Build, Operate and Maintain with Implementing Agent

The DBOM (IA) model, estimates the risk adjusted cost of the contract implemented by an IA, which will obtain Private Sector loan funding to implement the project.

The escalated DBOM (IA) risk adjusted capital and operating costs are shown in **Table 11.4**.

**Table 11.4: DBOM (IA) operating costs after risk adjustment**

Cost Component	Western Basin	Central Basin	Eastern Basin
	R million	R million	R million
<b>Capital Costs</b>			
Escalated Capital Expenditure after VAT (excluding risk)	2 001	3 190	3 998
Risk	417	665	833
<b>Risk-Adjusted capital cost</b>	<b>2 418</b>	<b>3 855</b>	<b>4 831</b>
<b>Operations Costs</b>			
Escalated Operational Expenditure after VAT	291	365	403
Risk Adjustment	89	117	132
<b>Risk Adjustment Operating costs</b>	<b>380</b>	<b>482</b>	<b>535</b>

### c. Design, Build, Operate, Maintain and Finance Public Private Partnership

The DBOMF (PPP) model analyses the development of the bid from the Private Sectors' perspective to meet the same output specifications used in the DBOM (IA) model. Generally, the Private Party creates a special purpose, legally independent company, or SPV.

In addition to the generic assumptions, the assumptions listed in **Table 11.5** have been used for the SPV.

**Table 11.5: Economic assumptions or indices**

Description	Percentage rate
Corporate Tax	28%
Dividend Tax	0%
Internal Rate of Return (Real)	16%

The debt payments and the survival of the project will depend on the cash flows of the project, which will comprise a unitary payment from Government. The funding of the project will be a combination of debt and equity. The debt will be obtained from the financial institutions or development banks. Provision has been made for a Maintenance Reserve Account (MRA) and a Debt Service Reserve Account (DSRA), as it is forecast that the Lenders may require these accounts as part of their lending conditions.

The DBOMF (PPP) will be a fixed price contract, and the escalated capital costs are reflected in **Table 11.6**. VAT is not included since the Private party will fully recover any VAT paid.

**Table 11.6: DBOMF (PPP) Capital and Operating Costs**

Cost Component	Western Basin	Central Basin	Eastern Basin
	R million	R million	R million
<b>Capital Costs</b>			
Escalated Capital Expenditure excl. VAT (excluding risk)	1 719	2 741	3 434
Risk	0	0	0
<b>Risk-Adjusted capital cost</b>	1 719	2 741	3 434
<b>Operations Costs</b>			
Escalated Operational Expenditure excl. VAT	255	318	351
Risk Adjustment	0	0	0
<b>Risk Adjustment Operating costs</b>	255	318	351

There was no risk adjustment to the DBOMF (PPP) costs due to the reason that the risks that will be transferred to the Private Party in terms of the DBOMF (PPP) Agreement are taken into account in the assumed costing by the Private Party. The private sector typically puts its own capital at risk, funding its investment in the project with debt and shareholder equity. The agreement therefore transfers risk from the government entity to the private company, including service availability.

For the purposes of the DBOMF (PPP) option, an annual Unitary charge (including VAT) to be paid by the Department is determined. The expected annual unitary charge is summarized in **Table 11.7**.

**Table 11.7: DBOMF (PPP) Expected Annual Unitary Charge**

Description	Western Basin	Central Basin	Eastern Basin
	million	million	million
Real Annual Unitary Charge, incl. VAT	554	745	888

## 11.4 Value for Money

The NPV of all the risk adjusted options (*i.e.* PSC, DBOM and DBOMF (PPP)) are set out in **Table 11.8**, with comparisons between the different options in **Table 11.9** and **Table 11.10**.

**Table 11.8: Real Net Present Value for all the options**

REAL NPV OF CASH FLOWS	Western	Central	Eastern
	R million	R million	R million
PSC	4 964	6 895	8 018
Implementing Agency with DBOM	4 794	6 585	7 612
DBOMF (PPP)	4 675	6 290	7 496

### 11.4.1 Comparison of the PSC and DBOM (IA)

**Table 11.9: NPV Comparison of PSC and DBOM (IA)**

Description	Western	Central	Eastern
	R million	R million	R million
PSC	4 964	6 895	8 018
Implementing Agency	4 794	6 585	7 612
Total Net Value for Money IA with DBOM	170	310	406
VFM as % of PSC Price (IA with DBOM)	4%	5%	5%

The difference between the PSC and IA's is R 170 million for the Western Basin, R 310 million for the Central Basin and R 406 million for the Eastern Basin. In all the cases the net present value for the PSC is greater than that for the DBOM (IA), thus the DBOM (IA) gives better Value for Money (VfM) than the PSC.

### 11.4.2 Comparison of DBOM (IA) with DBOMF (PPP)

The table above demonstrated that the both the DBOMF (PPP) and IA with DBOM provides value for money compared with the PSC option, which is not recommended. Thus DWA should choose between the DBOM (IA) and DBOMF (PPP). The VfM percentages with the PSC as a base are compared in **Table 11.10**:



**Table 11.10: NPV Comparison of DBOM (IA) with DBOMF (PPP)**

Description	Western	Central	Eastern
	%	%	%
VFM as % of PSC Price DBOMF (PPP)	6%	9%	7%
VFM as % of PSC Price DBOM (IA)	4%	5%	5%
Difference	2%	4%	2%

The DBOMF (PPP) VfM as a percentage of the PSC is greater than the VfM of the DBOM (IA) as a percentage of the PSC. The net differences are 2% for the Western Basin, 4% for the Central Basin and 2% for the Eastern Basin.

In conclusion the Value for Money analysis of the projects shows that the DBOMF (PPP) option provides the Department with more Value for money more than the DBOM (IA).

## 11.5 Conclusions

The value for money analysis of the projects shows that both the DBOM (IA) and DBOMF (PPP) options have value for money compared to the PSC option.

The analysis shows that the DBOMF (PPP) option provides the Department with marginally more value for money than the DBOM (IA) option, and somewhat more than the traditionally procured PSC.

Thus, the option that provides best Value for Money of the three options considered is the DBOMF (PPP) where the Department contracts a Private Sector partner to design, build, operate, maintain and fund the LTS, as well as integrating into the operation and maintenance of the STI.

However, the differences in value for money are not very large and the model inevitably contain a number of assumptions, including the extent of risk, that can be transferred and the results would be affected if different assumptions are used.

The time to procure a DBOMF (PPP) contract will be a few months longer than the time to procure a DBOM (IA) due to a somewhat longer bid, evaluation and negotiation period.

This and other factors may be sufficiently compelling to Government that the DBOM (IA) is selected instead of the DBOMF (PPP).



## **12. RECOMMENDATIONS FOR IMPLEMENTATION**

### **12.1 Introduction**

The previous chapters described the Reference Project (Chapters 5, 6 and 7), as defined in Study Report No. 6. While the Reference Project could be implemented in full, there are a number of reasons why full implementation of the Reference Project for the next 50 years is not recommended. This chapter provides the background for implementation and describes the recommendations for implementation of a LTS for managing AMD.

### **12.2 The Environment for Planning Implementation**

#### **12.2.1 Water Quantity and Quality**

The LTS needs to be implemented against the background described in the previous chapters and on the premise that AMD from the Western, Central and Eastern Basins will need to be managed forever. The planning environment is constantly changing, and the following factors affecting the long-term planning need to be considered:

- The ECL and SECL may need to be adjusted from those proposed now, as the effect of pumping is monitored;
- The hydraulic gradient to the abstraction points will vary with time. Thus, the TOL and pumping head is likely to change in future;
- The quantity and quality of the water to be managed will vary with time, but the changes are impossible to quantify at present. Factors affecting the variability include:
  - The success of ingress control to reduce flow and contamination from surface sources of AMD;
  - The connectivity of the mine voids, which may change over time; and
  - The flow patterns to the abstraction point.
- The quality of the water being abstracted is expected to improve with time, if water can be abstracted from relatively shallow depths so that a large volume of water in the void remains static;
- The extent of these uncertainties can only be reduced once pumping has been under way long enough for steady state conditions to be established and suitable monitoring programmes have been in place for a number of years;
- The economic climate is changing and the value of gold fluctuates. The economic value of the remaining gold resources in the Witwatersrand basins is such that, at the right price, it may be economic to mine them, even at considerable depths;
- The realistic life of most of the infrastructure required will be 50 years or less. Tunnels and some concrete structures would be a notable exception;
- Many mechanical components, particularly in an AMD environment, require significant maintenance and may need to be replaced at regular intervals; and

- If, as recommended, O&M is to be contracted out, irrespective of whether or not it is linked to design and construction, the minimum contract period would be 5 years, but 10 years to 15 years would be preferable to allow the recovery of start-up costs.

### 12.2.2 Costs and Treatment Technologies

In addition to those uncertainties, it is clear from the preceding sections that:

- Technologies are continually developing. Those which are currently known and possibly cost effective but unproven, or as well as totally new and cost effective solutions, may become the preferred technologies in future;
- While capital costs will be high, the annual operating and scheduled overhaul and replacement costs for the LTS and STI together, are expected to be in the order of 15% of the capital cost;
- Pumping costs are about 15 to 25% of the total operating costs (mainly electricity) and pumping 10 Mℓ/d through a head of 10 m costs R 585 000/annum;
- In addition to the pumping cost, the total cost of treating 1 Mℓ/d of AMD varies between R 2.7 million and R 5.8 million/annum;
- About 40% of the annual operating costs are for chemicals;
- Between 15 and 20% of the annual operating costs are for the disposal of the sludge from the HDS and RO processes;
- The cost effectiveness of measures to reduce ingress should be evaluated against the pumping and treatment costs. Cost-effective measures should be implemented as soon as possible; The cost of adequate monitoring, particularly of the aquifers that are polluted, or are at risk of pollution, to allow the TOL to be optimised, is likely to be small compared to the cost of pumping;
- Although there are a number of treatment technologies that may be able to treat AMD to the required standard, the only technologies which have been proven for similar environments and similar volumes are HDS followed by conventional RO, with Ion Exchange for the extraction of Uranium;
- Mining companies are reclaiming the gold in old mine dumps, and Mintails is testing a process that uses raw AMD in their tailings treatment process. They use fewer chemicals than HDS and produce a waste product that is similar in character to tailings and can be disposed of on a Tailings Storage Facility (TSF). However, there are some uncertainties about the fate of some chemicals and the Uranium; and
- Any treatment processes that can reduce any element of the operating costs and waste disposal will have significant economic benefits.

## 12.2.3 Principles for Implementation

Given the environment described above, the following principles for planning implementation have been adopted:

- The LTS should be planned to limit capital investment in long-term infrastructure that may be rendered obsolete because new processes with lower lifetime costs are available and can be implemented within its useful life;
- Implementation of the LTS, after the STI, should be phased with a medium-term phase, not exceeding 15 years and subsequent long-term phase to follow;
- The LTS should not sterilise access to mineral resources;
- If Government is to fund the solution, only technologies that Government considers to be proven should be accepted;
- If private sector finance is to be allowed, then technologies that the banks consider proven, based on their specialist technical review, will be offered and can be considered. The possibility of the private sector being prepared to fund technologies that are currently at the pilot stage of development, or are used at large scale elsewhere in the world under different conditions, should be considered;
- Any opportunities to link AMD treatment with parallel initiatives, such as the removal of mine dumps and land rehabilitation to reduce pollution, the treatment of urban waste water or the use of waste products from waste treatment or industrial processes, should be explored in detail during implementation;
- Opportunities should be provided for unproven technologies, with the potential to treat AMD to acceptable standards and at lower operating cost, to prove their viability;
- Government should support the development of technologies since they will have long-term benefits for the country in the management of AMD, not only on the Witwatersrand; and
- In future, every opportunity should be taken to introduce new technologies with lower operating costs, without introducing unacceptable risks.

## 12.3 Proposals for Implementation in the Western Basin

### 12.3.1 Introduction

The Reference Project, described in Section 5.3, has been used for the technical due diligence, economic assessment and value assessment, funding and cost-recovery proposals. Although the LTS concurred with the STI that HDS is the only proven technology for neutralisation of AMD, the ideal situation is that in the long term, neutralisation and the removal of heavy metals forms part of an integrated process procured under a DBOM contract, including neutralisation and desalination.

## 12.3.2 Proposals for Implementation for the Medium-Term

Since the Immediate Works have stabilised the situation, there is no urgency to implement the HDS plant proposed by the STI, and there is time to plan the procurement of an integrated treatment process through a DBOM contract in due course. However, a medium-term solution is required until it is decided to implement an integrated LTS.

### a. Critical Levels and Target Operating Levels

The ECL of 1 600 m amsl and TOL of 1 585 m amsl should be implemented and monitored as described in Section 5.3.2.

### b. Abstraction Points and Pumps

This Study concurs with the STI, which concluded that the RU Shaft No. 8 is suitably connected to the mine void, but a condition survey is recommended to check the stability before it is used for the installation of the STI pumps.

In the short term, the existing pumps will continue to be used to control the water level. The pumps to be installed by the STI will then draw down the water level to the TOL.

### c. Pumps and Pumping Rate

The STI pumps should be installed as planned by TCTA and should pump at the full capacity of the treatment works to draw down the water level in the mine void to the TOL. Thereafter, pumping should be maintained at a constant 23 Mℓ/d. The water level in the void should be monitored and the pumping rate adjusted if necessary.

### d. Ingress Control

A number of ingress areas have been identified in the Western Basin. These have been communicated to the relevant authorities. A number of large open pits, in particular the WWP and Millsite Pits, have been identified as significant ingress points. Every effort should be made to reduce the ingress.

### e. Treatment

#### i) Pre-treatment:

Pre-treatment for neutralisation and metals removal will be required until the LTS is implemented.

There are two possibilities:

- Gold One plant, which is currently being upgraded by TCTA, could be operated for as long as possible after the Pilot Treatment Plant phase, with further upgrade through the addition of a clarifier; and
- Mintails has proposed taking raw AMD and combining it with tailings from their gold extraction process in a Tailings Water Treatment (TWT) process, which produces tailings and neutralised AMD.

The acceptability of the Mintails TWT process is still being investigated. If it is suitable, and Mogale Gold obtains the necessary licences, it should be used for neutralisation, possibly for as long as 30 years. This would eliminate the need to add a clarifier to the existing Gold One plant. If Mintails provide the neutralisation process, they would also manage the resulting residues.

ii) Pilot Treatment Plants for Primary treatment:

In the Reference Solution, desalination would have been by RO. However, it is proposed that in the medium term, alternative technologies be tested as Pilot Treatment Plants.

Apart from the treatment technology selected for the Reference Project, a number of other technologies have been identified, but have not been proven at a sufficiently large scale or in a similar environment. If they were to be implemented now, there would be significant risk, but there could be significant cost savings if proved acceptable.

It is therefore proposed that the Western Basin be used to test promising, but unproven technologies in a number of Pilot Treatment Plants, each with a capacity of between 5 and 10 Mℓ/d. A capacity of at least 8 Mℓ/d would be preferred. Three or more such plants could treat the long-term average of 23 Mℓ/d expected to be pumped from the Western Basin, while four plants of 10 Mℓ/d would be required to treat the 40 Mℓ/d that is likely to be abstracted until the TOL is reached.

It is envisaged that, depending on the technology used, these plants could treat raw AMD directly from the shaft, or neutralised AMD produced by either the Immediate Works or the Mintails TWT process, or preferably both. Ideally, the plants should be tested using a range of possible feed water.

Because of the unproven nature of these technologies, it is envisaged that at least some of the treated water from such plants will not meet the specifications for potable or industrial water. However, the treated water will always be at least neutralised and generally have a significantly lower salinity than the neutralised water. It will therefore be beneficial if it is discharged to the Tweelopies Spruit, until water of a consistent and acceptable quality is being produced. Thereafter, it could be supplied to consumptive users.

These Pilot Treatment Plants should operate for 5 to 10 years, after which successful technologies should have been identified with confidence, and a new prequalification and tender process can be completed in which a range of technologies can compete against the Reference Project for LTS.

It is recommended that the WRC be the lead agency for procuring, managing and testing the Pilot Treatment Plants, supported by DWA and the Department of Science and Technology (DST).

**f. Ancillary Works**

Ancillary infrastructure such as balancing storage after neutralisation and pipework to transfer both neutralised and desalinated AMD will be required. Residue management facilities, discussed below, will also be required. Procurement of these works is discussed at the end of the next section.

#### **g. Residue Management**

The main residues will be sludge from the gold-recovery and neutralisation plants and Pilot Treatment Plant process, and brine from the Pilot Treatment Plant process. Some residues may have commercial value and could be sold or collected by users, but this is unlikely in the medium term.

If the Mintails TWT process is adopted, then Mintails would manage the residues from that process, and only the residues from the Pilot Treatment Plant (primarily sludge and brine) would have to be managed.

TCTA has an agreement with Mogale Gold in terms of which the sludge from the Immediate Works neutralisation plant is discharged into the WWP via a dam, which acts as a settling dam. However, the WWP has limited capacity and is expected to beach at the end of 2014 and to fill in about 2018. The current agreement does not allow for the discharge of sludge or other residues from the proposed Pilot Treatment Plants into the WWP, but this would be the most economic option. It is recommended that an agreement to allow this is negotiated with Mintails.

Mintails will only be able to consider accepting sludge from the Pilot Treatment Plants until 2018 when the pit will be full.

If Mintails will not accept sludge from the Pilot Treatment Plants, an alternative will be necessary; such alternative will be required anyway once when the WWP is full. One possibility would be co-disposal with the Mogale Gold tailings on their proposed new TSF once it is commissioned. The only other alternative would be a new SSF which will be required in the long-term as part of the LTS. A number of possible sites have been identified. Based on the total volume of sludge from the HDS process and from desalination that is expected to be produced over 45 years, the predicted final size of the SSF is 800 m by 600 m by 10 m high. However, this capacity would not be required if the HDS plant is not constructed.

The nature of the sludge from the Pilot Treatment Plants is unknown, but it has been assumed that it is such that the solids do not settle and it remains gelatinous, and unsuitable for constructing the perimeter wall of the SSF; waste rock will thus need to be imported for this purpose.

It is assumed that the sludge from the Pilot Treatment Plants will be classified as hazardous and that the SSF will be categorised as H:H in terms of the **“Minimum Requirements for Waste Disposal by Landfill”** (DWA, 1998). The site must therefore be lined, and a



leachate management system is required. Leachate and supernatant that does not evaporate must be pumped back to the treatment works and recycled.

Discharge of brine from the Pilot Treatment Plants into the WWP is undesirable because of the connectivity between the WWP and the void. It will therefore be necessary to construct the proposed LTS evaporation ponds. Two ponds, each measuring 340 m by 240 m by 2 m deep, are proposed.

Separate DBOM contracts should be procured for these, and other ancillary works, which are required to support the use of Pilot Treatment Works.

#### **h. Research**

The on-going research initiatives into the management of AMD should be encouraged.

In addition to the testing of Pilot Treatment Plants, the Western Basin can provide opportunities for researchers, including those supported by the WRC from universities and international organisations. The WRC is supporting the following research initiatives related to AMD:

- The BIOSURE process: A sustainable, long-term treatment option (WRC 2013a) with 3-year duration.
- The use of irrigation as part of a long-term neutralised AMD management strategy in the Vaal Basin (WRC 2013b) with 2-year duration.

### **12.3.3 Proposals for Implementation for the Long-Term**

In an attempt to identify an option for abstraction that would avoid the high electricity costs associated with pumping the AMD up a shaft, Study Report No. 5 considered the option of constructing a tunnel from just below the TOL to discharge by gravity. The most feasible option would be a 7.5 km long tunnel that would surface close to the Percy Steward WWTWs. This would have had particular advantages if a biological treatment process was to be adopted, or if the treated water was to be supplied to users below this level and in the vicinity, or discharged to the local stream.

However, because the treated water will probably be supplied to industrial users, possibly some distance away, the electrical energy used to raise the water up the shaft will not be wasted as it will contribute to the energy required to convey the treated water. There would then be no cost saving to offset the high construction cost of the tunnel or of the STI infrastructure, particularly the pumps at the shaft, which would become redundant.

The tunnel option is therefore not recommended in the medium term, but should be reconsidered when it has been decided:

- Whether or not the Mintails' TWT forms part of the solution;
- End-users for the water are confirmed; and

- Whether the biological treatment process is technically and economically viable with suitable sources of organic material.

Further investigations should be commenced in about 2016 when these factors are known.

If conditions for gravity abstraction are not favourable or further studies show it to be uneconomic, a new DBOM or DBOMF (PPP) tender for the required treatment, residue management and infrastructure for treated water should be procured.

## **12.4 Proposals for Implementation in the Central Basin**

### **12.4.1 Introduction**

The Reference Project, described in Section 6.3, has been used for the technical due diligence, economic assessment and value assessment, funding and cost recovery proposals. Although the LTS concurred with the STI that HDS is the only proven technology for neutralisation, the ideal situation is that the long-term neutralisation and heavy metals removal forms part of an integrated process procured under a DBOM contract, including neutralisation and desalination. The proposals for implementation are divided into two phases, medium-term for the next 15 years, using currently proven technologies, and a long-term phase for the period after that.

### **12.4.2 Proposals for Implementation in the Medium-Term**

#### **a. Critical Water Levels**

The recommended ECL is 1 520 m amsl with a long-term TOL of 1 500 m amsl, with an initial TOL of 1 470 m amsl. By the time the STI is commissioned, the water level in the void is expected to be at about 1 495 m amsl (i.e. a freeboard of 25 m); the water level should then be lowered to 1 470 m amsl to give an initial freeboard of 50 m below ECL of 1 520 m amsl so that the behaviour of the void can be monitored without risking breaching the ECL. The freeboard and thus the TOL to protect the ECL should be adjusted in future, based on the monitoring of the water levels in the void across the basin.

Drilling and water quality testing in the ERPM area are recommended to improve the definition of the depths of the shallow aquifer and provide baseline water quality data, which will enable a more accurate elevation to be determined for the ECL.

The underground museum at the GRCTF on 5 Level (1 484 m amsl) in CM No. 14 Shaft was taken to be the critical factor in determining the SECL-1. A long-term TOL SECL of 1 454 m amsl is proposed if the SECL is to be protected, but the behaviour of the water level in the void at this shaft should be monitored to verify this. Alternative SECLs of 1 396 m amsl and 1 246 m amsl, about 250 m and 400 m below surface at SWV Shaft are being considered to allow mining to that depth. If this takes place, the TOL to protect either SECL-1 or the ECL will have to be set before mining operations close down and the water is allowed to rise.

Whatever levels are set, monitoring of the near-surface aquifers of the basin is very important.

## **b. Abstraction Points**

It is recommended that abstraction be from the SWV Shaft.

However, to mitigate the risk that the effectiveness of abstraction at the SWV Shaft may at some time be reduced, additional abstraction strategies have been identified. Detailed investigations should commence as soon as possible so that a contingency plan is available. They are described in more detail in Chapter 2. Detailed investigations should commence as soon as possible so that a contingency plan is available.

A preferable long-term approach would be to abstract at SWV Shaft and up to four other locations. Also, a ventilation shaft about 500 m north-west of the SWV Shaft could serve as a back-up pumping location in the event of problems with SWV Shaft.

## **c. Pumps and Pumping Rates**

The pumps procured for the STI can pump the volume of 46 Mℓ per 19-hour day, or 58 Mℓ per 24-hour day, which is anticipated to be required and can pump from the required depth range of possible shallower depths and should be used. If multiple abstraction sites should be adopted, then multiple smaller pumps would be required, with some combined capacity.

## **d. Treatment**

### **(i) Pre-treatment:**

The 46 Mℓ per 19-hour day HDS plant being constructed and commissioned by TCTA should be used for at least the medium-term (15 years).

### **(ii) Primary treatment:**

If a DBOM contract is used, then it is recommended that the specifications require a proven technology for desalination, and it is anticipated that RO will be the core of most tenders on acceptable technologies could include others for which the Private Sector will take the technical and financial risk.

### **(iii) Secondary treatment:**

The inclusion of Ion Exchange technology by any tenderer is likely to be based on economics. If Ion Exchange is used to treat the full flow of raw AMD, the costs will be high, but all the Uranium will be removed and could have commercial value. The residues derived from neutralisation and desalination will then be free of Uranium, which will make the waste disposal less expensive.

Depending on the end-user, chlorination may be required.

## **e. Water Use**

It is recommended that the water be treated to a suitable standard and supplied to Rand Water who has current and potential industrial consumers to whom they will be able to sell the full volume of treated water from the basin. The required quality will depend on the users and their application.

#### **f. Residue Management**

##### **i) Sludge:**

For the STI, the neutralised sludge was to be pumped to the existing Ergo regional TSF for co-disposal with their tailings. However, this is no longer the intention and alternatives are being investigated. The desalination plant will produce a similar volume of sludge as the HDS plant and the STI planning should allow for this volume.

##### **ii) Brine:**

Purpose built brine evaporation ponds should be constructed.

#### **g. Research**

Institutions carrying out research may request batch samples or small flows of AMD at various stages of treatment. These requests should, wherever possible, be accommodated in order to develop more viable technologies for future use.

### **12.4.3 Potential Role of Package Plants**

RO package plants could possibly be installed and commissioned downstream of the HDS plant in less than 12 months from placing an order, possibly 24 months before the LTS can be commissioned. This would immediately reduce the salt load in the Vaal River System and the risk of water restrictions from 2015. Another advantage of such plants is that they can be moved from one site to another if necessary. However, they are significantly more expensive than more permanent treatment plants.

The use of package plants is not recommended at this stage, but it is recommended that the Department direct TCTA to assess the costs and availability of package plants, as well as how much time can be gained and at what cost.

### **12.4.4 Proposals for Implementation for the Long-Term**

Depending on the success or otherwise of the Pilot Treatment Plants proposed for the Western Basin, the possibility of other treatment options with lower operating costs, and ideally producing less waste to be disposed of, should be considered in the longer term.

A new DBOM or DBOMF (PPP) contract should be procured in sufficient time for it to be RfO before the expiry of the medium-term contract.

The bidders would be free to use the medium-term works should they so desire. However, it is possible that the contract may require abstraction at multiple abstraction points.

## 12.5 Proposals for Implementation in the Eastern Basin

### 12.5.1 Introduction

The Reference Project, described in Section 7.3, has been used for the technical due diligence, economic assessment and value assessment, funding and cost recovery proposals. The LTS concurred with the STI that HDS is the only proven technology for neutralisation, and the ideal situation is that neutralisation and heavy metals removal forms part of an integrated process procured under a DBOM contract, including neutralisation and desalination. The proposals for implementation are divided into two phases, medium-term for the next 15 years, using currently proven technologies, and a long-term phase for the period after that.

### 12.5.2 Proposals for Implementation for the Medium-Term

#### a. Critical Water Levels

In the Eastern Basin, an ECL of 1 470 m amsl, about 100 m below the water table in the dolomitic aquifer, is expected to be low enough to protect the aquifer from pollution. A long-term freeboard of 20 m is proposed, giving a TOL of 1 450 m amsl. However, it is recommended that initially a conservative ECL of 1 280 m amsl, at the base of the dolomite, with a TOL of 1 260 m amsl, i.e. no freeboard, be adopted.

The conservative ECL in the Eastern Basin (1 280 m amsl), which has been recommended for initial use, is estimated to be reached by mid-2014, but the STI will probably only be commissioned in December 2014. It is recommended that, if adequate monitoring of the dolomitic aquifer is in place, the water level is held at the level which has been reached at the time the STI is RfO, provided that it is below TOL-1 of 1 450 m amsl (i.e. the water level at the time of RfO is adopted as the initial TOL).

If adequate monitoring of the water quality in the dolomite has been established, and no pollution is observed at the ECL of 1 280 m amsl (associated TOL also 1 280 m amsl), the water level can be allowed to rise, possibly as high as 1 450 m amsl, provided that no AMD pollution is not detected. No SECL is currently set for the Eastern Basin.

#### b. Abstraction Points

In the Eastern Basin, Grootvlei No. 3 Shaft should be used for abstraction. The ground level at the shaft is below the 1:100 year floodline, and the STI proposes to raise the shaft collar above the floodline. An extensive rock or earth platform to a level of 1 573 m amsl is proposed to raise the LTS works above the floodline. This area is already highly impacted by past mining activities, and the environmental impacts of the fill platform will thus not be significant.

At present, elevated flows in the Blesbokspruit are impeded by a disused road bridge about 0.5 km downstream of Grootvlei No. 3 Shaft and a disused railway bridge about 0.4 km further downstream. In the floodline model, it has been assumed that both bridges will have

been removed, and their demolition should be included in the construction contract for the STI.

Should an unforeseen problem arise with abstraction at this shaft, alternatives would need to be considered and Marievale No. 5 Shaft which is connected to both the Kimberley Reef and the Nigel (Main) Reef via haulages is the recommended alternative.

Based on an inventory of shafts in the Eastern Basin prepared by Gold One and a camera survey carried out by Mine Rescue Services, Marievale No. 5 Shaft was identified as the most suitable alternative. This shaft is located at a lower elevation, south of the dolomite and wetlands.

The mine void water level monitoring being carried out in the Eastern Basin has shown that in this basin, the water levels in the areas of consistent and sporadic mining vary independently of the water level in the main void. It is recommended that the number of shafts to be monitored be increased, and that the mine void level data be reviewed monthly to identify whether there are potential pollution risks from the rising water levels in unconnected voids. Additional abstraction sites may need to be identified and abstraction and treatment implemented.

#### **c. Pumps and Pumping Rates**

Pumps procured as part of the STI, with capacity of 80 Mℓ per 19-hour day, and 100 Mℓ per 24-hour day, should be retained as part of the LTS.

#### **d. Treatment Works**

##### **i) Pre-treatment:**

The HDS neutralisation plant with an average capacity of 80 Mℓ per 19-hour day will be used.

##### **ii) Primary treatment:**

It is recommended that the specifications for the proposed DBOM or DBOMF (PPP) contract require a proven technology for desalination, and it is anticipated that RO will be the core of most tenders.

The inclusion of Ion Exchange technology by any tenderer is likely to be based on economics. If Ion Exchange is used to treat the full flow of raw AMD, the costs will be high, but all the Uranium will be removed and could have commercial value. The residues derived from neutralisation and desalination will then be free of Uranium, which will make the waste disposal less expensive.

##### **iii) Secondary treatment:**

Secondary treatment could comprise chlorination, depending on the user.

### e. Water Use

It is recommended that the water be treated to a suitable standard and supplied to Rand Water who has advised that they have current and potential industrial consumers to whom they will be able to sell the full volume of treated water from the basin as soon as possible. The required quality will depend on the users and their application.

The Department should negotiate with Rand Water to secure an end-user agreement for collecting the water at the Eastern Basin Treatment Works and arranging the necessary distribution infrastructure.

### f. Residue Management

The main residues are expected to be sludge from the HDS plant and RO process, and brine from the RO process. Some residues may have commercial value and could be sold, or at least collected by users.

The STI had provisionally arranged that neutralised sludge would be pumped to the existing licensed regional TSF operated by Ergo for co-disposal with their tailings. However, in June 2013, Ergo advised they would not be able to accommodate any sludge from the Eastern Basin (HDS or RO) at their TSF. It is proposed that the STI construct a stand-alone SSF to accommodate both HDS and RO sludge on the site identified by the LTS.

Separate brine evaporation ponds should be constructed.

## 12.5.3 Potential Role of Package Plants

RO package plants could possibly be installed and commissioned downstream of the HDS plant in less than 12 months. This would immediately reduce the salt load in the Vaal River System and the risk of water restrictions from 2015, possibly 24 months before the LTS can be commissioned.

Apart from the cost and logistical considerations, the HDS plant is likely to be fully operational by early 2015. It is possible that the long-term desalination plant could be operational by 2018, so the package plants would only be required for 3 years.

It is not recommended that package plants be pursued further.

## 12.5.4 Proposals for Implementation for the Long-Term

It is recommended that a new DBOM or DBOMF (PPP) contract be procured in sufficient time for it to be RfO before the expiry of the medium-term contract.

The bidders would be free to use the medium-term works should they so desire. However, it is possible that the contract may require abstraction at multiple abstraction points.



## 12.6 General

It will be important to ensure that water level recorders and water quality sampling points are established and monitored at enough points across each basin to provide sufficient data to determine the hydraulic gradient and changes in void water quality. This information, together with the data from the operation of the STI and the LTS, should be continually assessed to optimise the operation of the works, and then used for the design of the next phase of the LTS.

The proposed phasing is summarised in **Table 12.1**.

**Table 12.1: Proposed Phasing of Implementation Target date for commissioning**

Year	Western Basin	Central Basin	Eastern Basin
2012	Phase 1A: from 2012 for as long as required: – Upgrade neutralisation plant at 32 Mℓ/d.		
2013	Phase 1B: 2013: – Install permanent pumps; – Upgrade neutralisation capacity to 40 Mℓ/d; – Install permanent clarifier. – Alternatively implement joint neutralisation process with Mintails.		
2014		Phase 1A: from 2014 for as long as required: – HDS for 46 Mℓ/d.	Phase 1: 2014 for as long as required for: – HDS 80 Mℓ/d
2015	Phase 2: for 5 – 7 years: – Construct ancillary works; – Commission Pilot Treatment Plants (each 5 to 10 Mℓ/d) to develop innovative technologies, using physical, biological and chemical treatment processes		
2016		Phase 2: 2016: – Procure DBOM or DBOMF (PPP) contract for 10 to 15 years with Conventional RO.	Phase 2: 2016: – Procure DBOM or DBOMF (PPP) contract for 10-15 years with Conventional RO.
2020	Phase 3: ±2020 for 25 years. – Procure new process and operating contract with lowest lifetime and operating costs.		
2030	–	Phase 3: ±2030 for 25 years: – Procure new operating contract and process with lowest lifetime costs.	Phase 3: ±2030 for 25 years: – Procure new operating contract and process with lowest lifetime costs.
2040	Phase 4: 2046 for 25 years.		
2050	– Procure new process and operating contract with lowest lifetime costs for 25 years.	Phase 4: ±2055 for 25 years: – Procure new operating contract and process with lowest lifetime costs.	Phase 4: ±2055 for 25 years: – Procure new operating contract and process with lowest lifetime costs.



## 13. IMPLEMENTATION STRATEGY

### 13.1 Cost Recovery

The underlying basis for recovering the capital and operating costs of the LTS and the operating costs of the STI, which will be incorporated into the LTS, will be that the polluter and the user pay.

It is envisaged that DWA would wish to recover all or most of the cost of the capital and operating costs of the project from the polluters and the beneficiaries or users, in line with Government and Departmental policy. However, the Department may fund some of the costs from its annual operating budget.

Government would manage the collection of the income streams from the various sources and ensure that the total income is equal to Government's project costs.

The opportunities for cost recovery are:

- Polluters pay:
  - Cost recovery from mines;
  - Contributions from mines' Trust Funds;
  - Cost recovery from the WDCS; and
  - Cost recovery from a future Environmental Levy or mining tax.
- Beneficiaries and users pay:
  - Cost recovery from the VRT.
- Income from the sale of raw AMD water to Mintails; and
- Sale of treated water to Rand Water.
- Other possible income streams are from the sale of residue products with a commercial value, including Iron, Uranium and gypsum, but these are assumed to be for the benefit of the contractor.

Collection of the funds from the polluters and determination of the appropriate tariff should be carried out by DWA. The Department should also collect the funds and distribute them to the appropriate parties to offset the costs incurred in the management of the LTS.

#### 13.1.1 Cost Recovery from Mines and other Possible Liable Parties

##### a. Introduction

The possible apportionment of liabilities for addressing the AMD-related pollution and other negative impacts from the generation of AMD in the three basins was investigated. The following questions were considered:

- Who can be held legally liable for the negative effects and damages of AMD-related pollution and/or any negative impact from AMD generation?

- What are the legal responsibilities of the State and potential Governmental exposure?
- What alternative approaches could be considered for apportioning liabilities?
- How can the mines' Provisional Funds be utilised?

The following recommendations are given:

- A strategic approach to addressing liability and recovering costs in the three basins; and
- Possible changes in current/possible future legislation to effectively address the challenge of AMD.

#### **b. Legal Liabilities**

The mining sector has incurred certain legal liabilities, currently and/or historically. There are various considerations in applying and implementing the law to offset the capital and operating costs to be incurred by Government:

- Certain persons/companies/institutions that may be legally liable may accept this liability and may wish to proactively and freely contribute to the solution (e.g. by providing land or land rights or access to land, providing materials, manpower, management responsibility, or funds, etc.). This may occur through a negotiated agreement, which may entail practical or pragmatic negotiations or contributions not necessarily based on law; and
- Other persons/companies/institutions that may be legally liable may not (or not to a reasonable extent) accept this liability and thus not proactively and freely contribute to the solution. In this case, Government may decide to enforce the law.

The decision to enforce the law will have to be assessed and decided on a case-by-case basis.

Alternative approaches to apportioning liabilities are discussed in the Confidential Study Report No. 4. This report will be made public once it has served its purpose in supporting Government's cost-recovery initiatives.

#### **c. Engagement Strategy**

The recommended approach to the recovery of costs from the mining sector is described in the Confidential Study Report No. 3. This report will be made public once it has served its purpose in supporting Government's cost-recovery initiatives.

The general recommendation is that an Inter-Governmental Legal Task Team be established between the relevant Government institutions that need to take all negotiations and legal actions forward.

Recovering costs from the mining sector will be a time-consuming process, and quantification of the contributions that will be obtained is not yet possible. It should currently not be considered as a source of funding, which can be relied on for implementation, but should be a major component of the process of cost recovery.

#### d. Mines Provisional Funds

Moneys set aside as provision for rehabilitation purposes can, under certain circumstances, be utilised by the Minister of Mineral Resources for AMD management where holders of new order or old order prospecting or mining rights are liable to pay for rehabilitation.

These funds are not very large and are not envisaged to be a significant component of the cost recovery.

#### 13.1.2 Cost Recovery Using the Vaal River Tariff

The VRT was originally introduced to repay the loans raised by South Africa, through TCTA, to finance Phase I of the LHWP. It has since been expanded to recover the cost of implementing, operating and maintaining other water resource projects in the Vaal River System. Since the water from the Central and Eastern Basins naturally forms part of the resources of the Vaal River System, the VRT can be used to recover the cost of managing AMD in those basins. Since it is also recommended that the fully treated water from the Western Basin be sold to Rand Water, it effectively becomes part of the resources of the Vaal River System. The VRT could thus be used to cover the cost of the LTS for this basin. It may not be possible to use the VRT to cover the cost of Pilot Treatment Plants, but this should be investigated. The VRT is invoiced to users and collected by the Department, which distributes the income to various projects, including those undertaken by TCTA. The tariff is calculated by TCTA, based on data provided by, or agreed with the Department. The model used for the current tariff calculations has been applied by TCTA for the several scenarios to recover the cost of managing AMD in the Central and Eastern Basins. The Department must now decide on how the VRT should be used for cost recovery.

#### 13.1.3 Cost Recovery through Waste Discharge Charge System

The Department has initiated the WDSCS, a tool that will be used to support existing water quality management initiatives, to promote waste reduction and water conservation. The WDSCS has been developed around the “polluter pays principle”, and the use of economic instruments and aims to:

- Promote the sustainable development and efficient use of water resources;
- Promote the internalisation of environmental costs by polluters;
- Create financial incentives for dischargers to reduce waste and use water resources in a more optimal way; and
- Recover costs associated with mitigating the water quality impacts of waste discharge.

The WDSCS consists of two charges:

- The **Waste Discharge Levy** seeks to change discharge behaviour and is an unrequited payment (in that it does not recover any direct costs and is not related to receiving a particular service). The Waste Discharge Levy is thus an environmental tax, which requires the promulgation of a Money Bill in terms of NT’s environmental tax policy.

- The **Waste Mitigation Charge** is intended to cover the costs of mitigation measures undertaken for the benefit of the water resource and will be applied in cases where it is more cost-effective to undertake joint measures for waste discharge mitigation.

The WDCS is being piloted in the Upper Olifants, Upper Vaal and Upper Crocodile Catchments. The Waste Mitigation Charge could potentially be used to recover some of the costs of managing AMD. Discussions on whether the charge would penalise those mines/companies that are already taking measures to mitigate the risks of AMD, and manage their pollution in the Vaal River System, needs to be further discussed between the Department and NT.

#### 13.1.4 Environmental Levy

The “polluter pays principle” is taken up in the NEMA (107:1998) principles:

Section 2 (4) (p), “The costs of remedying pollution, environmental degradation and consequent adverse health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment.”

Further, the South African Revenue Service (SARS) is already responsible for collecting several environmental levies for various purposes. A potential disadvantage of levies collected by SARS is that they go into the general revenue fund and cannot easily be ring-fenced for use on a particular project.

The WRC intends to carry out a study on behalf of the Department into the viability of using an Environmental Levy to recover costs incurred in managing AMD.

#### 13.1.5 Conclusions

The amounts that will be recovered from the mines are too uncertain in both quantum and timing to be relied on in planning. The funding to pay interest and redemption on any capital loans and to cover the annual operating costs, which will include a maintenance reserve account to provide for major maintenance, refurbishment and replacement requirements, will thus, at least initially, come from a combination of the VRT, the WDCS and the National Treasury (NT) through the Department’s annual budget. However, once the contributions from the mines are known, the tariffs are being charged to other polluters (WDCS) and users (VRT) can be adjusted.

### 13.2 Revenue Collection

Discussions with some of the commercial banking market have indicated that the project attractiveness is enhanced by the Private Party not being exposed to revenue collection risk. Should the service provider be exposed to revenue collection risk, then the Lenders would have to carry out a due diligence on the receiving party who would be liable for payment and

this would probably result in either the project not being bankable or attracting a premium to the lending rate. The project has thus had income risk removed by routing all income collection through the State, except for the minor and uncertain revenue generated from the sale of waste products for which there could be some form of profit sharing agreed.

## **13.3 Procurement Methodology**

### **13.3.1 Introduction**

Whichever source of funding and implementing structure is used, the contract that will be procured will be a DBOM. The DBOM contract or DBOMF (PPP) contracts are similar, with the exception of the funding arrangements. The procurement methodology will require that the requirements, brief and performance monitoring regime for the contract are carefully documented, with a clear indication of the deliverables to be achieved and the allocation of risk.

Procurement will be a two-stage process, in which the first stage will be a qualification stage to achieve a shortlist of pre-qualified bidders, and the second stage will be a RfP. The shortlisted bidders will be invited to respond to the RfP document, which will require a response from bidders as to their technology offering, operations methodology, management structure and processes, risk mitigation strategies and the cost of delivering treated water.

#### **a. Procurement Team**

The Feasibility Study process, including approval by NT, has to be completed prior to the commencement of the procurement process. On completion of the Feasibility Study and prior to starting procurement, the implementer will secure the services of a PSP team as Transaction Advisors team to support the implementer, being either the Department or the appointed IA, in the drafting of the procurement documentation, the assessment of the bids received and in any negotiations that might take place. The Transaction Advisor will be a multi-disciplinary team with contractual procurement, technical, financial and legal skills and will have the role of preserving the position of Government as the implementer and securing the required risk allocation position of Government through the process of procurement and negotiations.

#### **b. Output Specifications**

In the procurement of a DBOM or DBOMF contract, the procurement and contract documentation specifies the output that has to be achieved – the delivery of treated water to a certain specification. The Department defines the service or outcome that it needs to deliver, or the objectives to be achieved, and then leaves the methodology of implementation to the service provider.

The concept of output specifications entails a change in how the Department views the delivery of its services. Instead of procuring infrastructure, the Institution will consider procuring the service with specified outputs.

Performance of the contracted operator would be monitored on an on-going basis, both by the operator itself and by the implementer. Performance would be secured, in that payment would only be made for the delivery of treated water that meets the agreed specifications.

Even in the case of a DBOMF (PPP), where funding of the assets had been secured by the Private Party SPV, ownership of the assets would reside with the Department, provided that the assets developed were located on state land or were constructed on private land as “Government Water Works”, with the agreement and consent of the land owner.

This can be compared with conventional or traditional procurement which uses input specifications and specifies the inputs required to achieve the required outcome.

Specifying inputs excludes the possibility of alternative solutions that bidders could come up with, and may inhibit innovation. Risk allocation will be affected, as the specified input usually prevents appropriate risk transfer.

### **c. Transaction Advisor**

Given the recommendation for a DBOM procurement solution with capital funding from either the Revenue Fund or the Private Sector to an IA or SPV, it is advisable for a DBOM, and required for a DBOMF, that a Transaction Advisor be procured to work with the Department to assist in the management of the procurement process for securing contracts with a Private Party. For a DBOMF (PPP), this needs to be in accordance with the systems and standards set out for PPPs in Treasury Regulation 16, using NT's PPP Manual and Standardised PPP Provisions. For a DBOM, the manual and standardised provisions would be recommended as a guide.

### **d. Project Finance**

Project financing is a loan structure that relies primarily on the project's cash flow for repayment.

Non-recourse funding is a loan where the lending bank is only entitled to repayment from the profits of the project that the loan is funding, not from other assets of the borrower. These types of projects are characterised by high capital expenditure, long loan periods and uncertain revenue streams.

Limited recourse funding is a loan in which the Lender has limited claims on the loan in the event of default. Limited recourse debt sits in between secured bonds and unsecured bonds in terms of the backing behind the loan. Often, a limited recourse debt contract is structured so that the debt transitions to unsecured, or "non-recourse" debt, pending the completion of a specific event. Limited recourse debt will typically pay a lower rate than standard issue unsecured bonds because of its relative safety. Claims on limited recourse debt sit above both stockholders and unsecured bondholders in terms of pay-out hierarchy.

## **e. Equator Principles**

The Equator Principles are a financial industry benchmark for determining, assessing and managing social and environmental risks in project financing. The South African banks are signatories to the Equator Principles, which requires them to ensure that the projects that they finance are developed in a manner that is socially responsible, and that they reflect sound environmental management practices.

## **13.4 Procurement Process**

### **13.4.1 Introduction**

The procurement process will have the objective of securing the services of a service provider with the competency and capability to provide a fully integrated treatment facility and service for AMD under a DBOM or DBOMF (PPP) contract. The design of the LTS, construction of the designed solution, supply of technology and integration or replacement of the STI will be required, so that the operation provides a sustainable treatment and waste management solution for AMD in the medium-term. The service provider will also have to be able to operate the infrastructure provided for the LTS, as well as that provided for the STI and integrated into the LTS. The medium term in this instance is defined as a period exceeding 10 years, but with a long-term horizon stretching over decades.

### **13.4.2 Procurement Process**

The tender documentation will need to be flexible enough to protect possible intellectual property of tenderers, and provide for variations of DBOM.

The Department or IA will appoint a PSP as Transaction Advisor, which will be a multi-disciplinary team, to assist the Department in the procurement and negotiation processes. The Transaction Advisor will be procured prior to the commencement of the procurement process.

A two-stage procurement process will be used, comprising a Request for Qualifications (RfQ) to select a short list of pre-qualified bidders, followed by a RfP. The evaluation process for both stages will utilise a Technical Assessment Committee, comprising members of the Department, the IA or Contract Management organisation and the Transaction Advisors. The objective for the evaluation of the RfQ submissions will be to achieve a shortlist of approximately three pre-qualified bidders who, in the opinion of the Evaluation Committee, will submit comprehensive and competitive bids that will meet the requirements of the documentation to be issued.

The two-stage process will enable the Implementer to issue RfP documents only to bidders that have been assessed as competent to submit proposals and will limit the number of proposals received, reducing the wasted effort by unsuccessful bidders and the time required for adjudication.



The RfP documentation for a DBOM or DBOMF (PPP) will be “output” based as opposed to “input” based, and will identify the outcomes that DWA or its appointed IA wishes to achieve.

The Procurement Phase includes the negotiations stage for which a negotiating strategy and list of negotiation issues will be developed at the time that the Preferred Bidder is notified.

In both the RfQ and RfP documents that are issued, there will be evaluation criteria so that the bidders will clearly understand the criteria to be used in evaluating their submissions.

The objective of the RfP evaluation is to recommend the appointment of a preferred and reserve bidder, both of whom are, in the opinion of the Evaluation Committee, capable of negotiating to closure a deal that will meet the requirements of the project, is affordable, provides value for money and has appropriate and substantial risk transfer from Government to the Private Sector.

There will be an evaluation manual based on the evaluation criteria in the RfQ and RfP, for use in technical assessment and by the Evaluation Committees.

### **13.4.3 Procurement Plan for the Western Basin**

#### **a. Pilot Projects**

The Western Basin will be used to procure a number of service providers who each have an emerging technology that has been shown to work, but not at the scale required to treat AMD in the Witwatersrand gold-mining basins. The emerging technology Service Providers will be procured through a competitive process that will be structured to identify the technologies with the best chance of commercially treating AMD in a cost-efficient manner.

It is expected that up to five Pilot Treatment Plants will be procured, which will (or should be) funded through a combination of capital funding from the Department of Science and Technology (DST), DWA, WRC and Private Sector investors. It is recommended that the WRC be the lead agency for procuring, managing and testing the Pilot Treatment Plants, supported by the Department and DST. The contract will be an output-based contract requiring the bidders to propose a Pilot Treatment Plant solution. The Pilot Treatment Plants will be contracted for about 10 years.

Two procurement processes will be required to implement the Pilot Treatment Plant programme:

- Contracts for procurement and testing of Pilot Treatment Plants; and
- Contracts for the ancillary works, including collecting and managing the residue products from the Pilot Treatment Plants. These are discussed separately in the following sections.

The physical layout, and hence some of the infrastructure requirements, will depend on whether the medium-term plan for neutralisation is the Immediate Works at the Gold One plant or the Mintails TWT plant.



i) Form of Contract:

The Form of Contract for the pilot projects will be a standard WRC research contract with purpose-designed financial arrangements.

ii) Scope of Contract:

There will be a separate contract with each of the proprietors of the technologies that are accepted for research. Each WRC research contract will cover the following:

- Infrastructure required to collect the neutralised water from a balancing reservoir;
- Site works required for the Pilot Treatment Plant and connection to the source reservoir;
- The Pilot Treatment Plant;
- Carrying out the agreed testing on the incoming water and all products from the plant;
- Infrastructure to take the three output streams;
- Treated water, sludge and brine, to agreed collection points; and
- Reporting.

iii) Contract period:

The contract period will be long enough to achieve the following objectives for each Pilot Treatment Plant:

- Establish the plants;
- Commission the plant;
- Test the operation for at least 48 months in order to demonstrate sustainable performance with variations in feed water; and
- Provide operating desalination facilities until Phase II of the LTS can be implemented, or until desalination is no longer required.

iv) Procurement process:

The established WRC process for receiving and assessing solicited research proposals would be followed.

A Reference Group would be established to evaluate the proposals received and to oversee the performance of the contracts.

v) Financial arrangements:

The financial arrangements for the Pilot Treatment Plants will be structured to meet the following objectives:

- Technology development for managing AMD for the long-term benefit of the country should be encouraged;
- The Private Sector should be committed to use the best resources at their disposal to develop and prove their technologies;

- The Private Sector should not be exposed to undue risk if the upstream processes and facilities do not perform within defined limits or to agreed standards.
- Government should pay an appropriate tariff for water treated to an agreed standard; and
- The Private Sector should make investments in developing their technology commensurate with their potential long-term benefits.

#### **b. Ancillary Works**

The following ancillary works will be required:

- Provision of collecting or balancing storage between the neutralisation works and the Pilot Treatment Plants; and
- Facilities to manage the residue streams (sludge and brine) from each of the Pilot Treatment Plants.

There are two options for the management of residues:

- If Mogale Gold/Mintails provide the neutralisation process, including managing those residues, they could be contracted to manage the residues from the Pilot Treatment Plants, possibly using the WWP for the sludge. Brine should be managed in a separate facility. The contract could include the provision of other ancillary facilities. This would not be an open procurement process; and
- A DBOM contract could be procured specifically to manage the residues from the Pilot Treatment Plants, irrespective of the neutralisation process being used. It should include the other ancillary facilities.

##### **i) Scope of Contract and Duration:**

In either case, the scope of the contract would include:

- Providing a balancing reservoir and associated pumps and pipelines between the neutralisation plant and the reservoir;
- Providing the infrastructure to receive the residue streams from each Pilot Treatment Plant; and
- Providing the infrastructure required (e.g. SSF and brine evaporation ponds to manage the residues).

The residue management facilities should be planned to manage the residues from a desalination process for 45 years. However, the construction of the SSF should be phased.

##### **ii) Procurement Process:**

Given the relatively specialist nature of designing, constructing, operating and maintaining the envisaged residue management facilities, a single stage RfP open tender procurement process is proposed.

### iii) Financial Arrangements:

The financial arrangements for the ancillary infrastructure should be structured to:

- Reimburse the DBOM contractor for capital works through milestone payments; and
- Reimburse the DBOM contractor on a monthly basis for satisfactory operation of the works.

Government or the Private Sector could fund the Works. There is no obvious revenue stream, but Government could pay on the basis of Rand/Ml of brine managed according to the specifications.

## 13.4.4 Procurement Plan for the Central and Eastern Basins

### a. Form of Contract

The contract in the Central and Eastern Basins should be either a DBOM or DBOMF (PPP), as decided by DWA. The advantages and disadvantages of each are discussed in the Confidential Study Report No. 7. A DBOM contract would be an output specification-based contract requiring the service provider to provide a fully integrated DBOM service.

A DBOMF (PPP) contract would be based on the Standardised PPP Provisions first issued in March 2004 (National Treasury, March 2004), as amended.

The contract, whether a DBOM or DBOMF (PPP) contract, would be drafted with the support of a skilled Legal Advisor. The contract would be discussed and agreed by a team, comprising the Transaction Advisor and DWA, and would benefit from inputs from NT.

### i) Number of contracts:

There would be a separate contract with separate service providers per basin, given their varying sizes and differing raw water qualities. There will be no constraint on the same bidder being successful in the Central and/or Eastern Basins and also having a Pilot Treatment Technology in the Western Basin.

### ii) Scope of Work:

The Scope of Work (SoW) is summarised as follows:

- Take over, operate, maintain and, where required, refurbish and replace components of the STI;
- Design and construct the infrastructure, technology and operating process to treat raw AMD and manage the residues from the full process. It would be expected, but not required, that the STI infrastructure would be incorporated into the LTS, in which case, the new treatment works would be for desalination. Should the STI not be incorporated into the LTS, then provision will be made for mothballing the components of the STI that are not required. The mothballing will be such that the mothballed plant can be recommissioned on the expiry of the contract should the need arise;

- Construct the infrastructure that has been designed, and supply the required technology equipment and all associated plant and equipment;
- Commission the supplied plant and constructed infrastructure;
- Integrate the STI into the LTS and balance the system so that a continuous flow of treated AMD is achieved with the designed percentage or less of waste and brine;
- Operate all the works and residue management facilities for the duration of the contract, providing and being reimbursed for producing treated water from the raw AMD;
- Where possible, produce residues with a market value and a market, and sell these in an accountable and transparent manner;
- At about three years from the expiry of the contract, support the Department in securing a replacement Service Provider contract;
- At or about two years from the expiry of the contract, undertake a dilapidation survey of the project assets; and
- If required on expiry of the contract, hand the operational facility over to the Department.

iii) Contract duration:

The LTS for the treatment of AMD will need contracts for the foreseeable future, say 100 years. In the process of researching the issue, it has been found that a shorter-term contract would be preferable to a long-term contract. It is proposed that the contract will be a 15-year operational contract, which will be of sufficient length to minimise the annual capital repayment and sufficiently short that a new technology could be acquired that would reduce the operational costs.

iv) Procurement Plan:

The implementation of the project after achieving Treasury Approval 1 (TA 1) will be:

- Procuring an EIA consultant;
- Completion of the EIA process for the three basins. EIA approval will have to be achieved prior to any construction commencing;
- Procuring a Transaction Advisor;
- Procurement with RfQ and RfP stages;
- Negotiations to contract signature and financial close;
- Development, including design, construction of infrastructure, supply of technology, commissioning of plant and equipment, and handover to the operations sub-contractor;
- Operations commencement and system balancing, leading to full operations for the duration of the contract;
- Asset maintenance; and
- Contract expiry activities.

Implementation will be operational when the constructed infrastructure and supplied technology are integrated with the STI and are continually producing the expected percentage of treated water to raw AMD, to the required quality specifications.

Once the contract has been signed and financial close has occurred, the successful service provider will take over the operations of the STI and prepare that operation for the completion of the construction of the LTS and its operational commencement.

v) Process for payment of Service Provider:

Payment for construction activities will be based on work completed. As the contract will be a fixed-cost, fixed-term contract, payment will be against interim milestones completed. Where the project is Government funded, the Implementer will appoint, with the approval of NT as the Funder, an Independent Engineer (which may be an organisation) as the Transaction Advisor, who will be responsible for certifying progress and the release of capital funds.

Where Private Sector funding is involved, the Lenders will appoint an LTA that will establish a milestone schedule against which payment will be made. If there is a Government contribution to the project, in addition to funding by the Private Sector, then the LTA will have a duty of care to Government during the certification process.

**b. General Conditions of Contract**

It is proposed that the contract be based on the International Federation of Consulting Engineers (FIDIC) General Conditions of Contract.

### **13.4.5 Approach to Broad-Based Black Economic Empowerment**

B-BBEE is a fundamental component of any major infrastructure development in South Africa. The Economic Assessment has shown that there will be significant benefits to the Gauteng community from this project. During construction, Black Economic Empowerment (BEE) contractors, both large and small, will be involved with local operators and those involved in the operations and maintenance of the plants. There will be opportunities for skills transfer to BEE companies and individuals.

The involvement of BEE companies and individuals will be achieved through appropriate wording in the procurement documentation and contract agreements, and the execution of the requirements will be monitored by the Performance Monitoring Team in each of the three basins.

### **13.4.6 Contract Management**

During the closing stages of negotiations, the Department or its IA (with its PSP) will need to draft a Contract Management Plan (CMP) to assist the Department in developing a good working relationship with the contracted service provider to achieve the objectives of the Project in a sustainable manner within the contract. The main purpose of the CMP is to:

- Demonstrate (to NT in the case of a regulated project) the capacity of the Implementer to effectively implement and enforce the agreement for the duration of the agreement;
- Provide a strategic management tool to guide the contract management;
- Indicate the activities that the Department, their Advisors and IA, and the service provider will undertake during each stage of the project;
- Clarify key institutional roles and responsibilities of the Department and the IA during each stage of the project and identify the resources that the Department will require to undertake these responsibilities;
- Provide information on the contract management approach and agreement management arrangements, which can be used to assess the performance of the Department in discharging its obligations and responsibilities, as set out in the Contract Agreement, and as may be required by Government legislation, such as the PFMA (1:1999); and
- Provide a vehicle for addressing issues that cannot be dealt with adequately in the Contract Agreement (such as attitudes and behaviours).

The responsibilities for Quality Assurance (QA) different slightly between a DBOM and a DBOMF (PPP) contract:

- In a DBOM-type contract, the service provider, in particular the member of the SPV responsible for operation, will be key in the design and implementation of the QA system. They will ensure that there is adequate monitoring of the design, technology installation and construction to ensure that the required functionality is achieved;
- The Department or IA, as well as any funders requiring repayment, will also have their own inspection regime to ensure that the requisite level of functionality is achieved; and
- A DBOMF (PPP) contract passes a level of risk to the Service Provider to ensure that the plant that is designed and constructed, and the technology supplied, will deliver the outputs expected. The Funder will implement its own QA systems, since poor or out-of-specification performances will attract penalties, and the revenue flow will be negatively impacted.

### 13.4.7 Development Supervision

The CMP will identify the structures and process to be used for the management of the contract during the development/construction stage. This will include monitoring of the design, the selection and procurement of the selected technology, the construction of infrastructure, and the installation of plant and equipment. When this is complete, the works will be certified as Ready for Commissioning (RfC). Thereafter, the commissioning, testing and integration of the STI infrastructure into the LTS infrastructure will be carried out. Once commissioning has been completed, the LTS and integrated STI infrastructure can be certified as RfO by the IA.

## 13.5 Risk Management

### 13.5.1 Introduction

It is proposed that as much as possible of the technical and financial risk be transferred to the Private Sector, preferably through a DBOMF (PPP) contract. Transferring risk incurs a cost, but the Value for Money Assessment (VMA) has shown this approach to be marginally more cost effective. Whether or not to transfer financial risk to the Private Sector through a DBOMF (PPP) contract or only transfer technical risk through a DBOM (IA) contract is linked to Government's policy decision on how to finance the implementation of the LTS.

A key part of the VMA was a detailed risk assessment of all the elements of the Reference Project for each basin. The size of the risk (value), the likelihood of its happening and the measures that should be put in place to minimise and manage the risk were described in the Confidential Study Report No. 7.

A mitigation strategy was identified for each risk. In summary, these risks can be mitigated and managed by:

- Sound planning;
- Appropriate procurement documentation and procedures;
- Appropriate financial contract management procedures at all levels;
- Appropriate quality assurance and management processes, systems and procedures;
- Sound contract management and supervision of implementation by competent well-staffed teams using tested processes and procedures;
- Appropriate oversight by the Department (the Special Project Unit (SPU)) and its support teams (IA, PSP Advisors, Contract Managers, etc.); and
- Comprehensive monitoring plans and reporting procedures to:
  - Identify and assess compliance with specifications;
  - Monitor water levels in the mine void;
  - Detect changes in the characteristics of the water in the mine void; and
  - Detect changes in the characteristics of the water in the surface streams and near-surface aquifers.

### 13.5.2 Risk Management Plan

In the Implementation Phase, a detailed Risk Management Plan will be prepared as part of the Project and Contract Management Plans.

The risk matrix that has been developed provides the responsible organisations and officials with enough insight to develop a Risk Management Plan.



For each Government or shared risk, the Risk Management Plan will set out the following:

- An evaluation of the different options for treating the risk;
- The Department official who will be responsible for managing the risk;
- The procedures and mechanisms that will be used to control the risk; and
- An estimate of the resources that the Department will allocate to managing the risk.

For each Private Party risk, the Risk Management Plan should set out:

- The obligations and reporting requirements that the Department has imposed on the Private Party to ensure that the risk is managed;
- The Department official who will be responsible for monitoring the risk;
- An estimate of the resources that the Department will devote to monitoring the risk;
- The mechanisms that will be used by the Department to deal with any failure of the Private Party to manage the risk, namely penalty deductions, step-in, etc.; and
- The Business Contingency Plan that the Department will follow to ensure continued service delivery in the event that the Private Party cannot maintain the service or the Department is forced to terminate the DBOMF (PPP) agreement for whatever reason.

Several of the risks are to the reputation or credibility of DWA, and must be managed by DWA, but many of the risks arise from areas where other National or Provincial Governments or LAs are responsible. It is very important that the responsible departments are fully aware of their responsibility and are held accountable by the Inter-Ministerial Committee (IMC) and Inter-Governmental Task Team (IGTT).

### **13.5.3 Management of Legal Risks**

There is a potential risk to Government in reaching any agreements with the mines on the use of their land, assets and TSF. In concluding such agreements, any exemptions or offsets that may be granted to the mines for potential liability should be clearly defined and understood by both parties.

If Government enters into agreements for the co-disposal of sludge from the HDS or RO processes with tailings, on a mine tailings dam or similar facility, the agreement should be clear that the mine retains all legislative responsibility for the facility.

It is recommended that proactive legal advice be sought on any form of uncertainty during implementation, due to the potential delaying impact that legal action could have.

Legal risk and contingency planning will have to be addressed in detail, as part of implementation process planning, by the IA, for each basin.

Law enforcement and/or litigation can be a very costly and time-consuming exercise, utilising the tax payer and Government funds, but in certain instances, depending on the cooperation of the parties concerned, law enforcement may be the only option.



## 13.6 Parallel Implementation Activities

The acquisition of land, or the right of access to land, and the completion of an EIA are required before contracts can be awarded and these are discussed below. Supplementary activities that are essential for the effective implementation of the LTS and which should be carried out in parallel with implementation are: Hydrological and Hydrogeological monitoring, as well as Communications with the public and stakeholders. These are discussed in Chapter 15.

There are also complementary activities, including ingress control and rehabilitation of mine dumps, which are important for the overall management of pollution from AMD. They are also discussed in Chapter 15.

### 13.6.1 Environmental Impact Assessment

#### a. The Exemption granted to DWA for the STI

TCTA, as part of its responsibilities for implementing the STI, initiated the required EIA process in terms of Section 24L of the NEMA (107:1998) EIA regulations.

On 27 November 2012, DWA applied to the Department of Environment Affairs (DEA) for an exemption in terms of Section 24M of NEMA (107:1998), and for authorisation to proceed with construction of the STI.

On 7 January 2013, the DEA granted DWA exemption from the NEMA (107:1998) 2010 EIA regulations, and authorisation in terms of NEMA (107:1998) and NEM:WA (59:2008) for the Immediate Works and STI. At that stage, the Scoping Study was complete and several specialist studies were complete or nearing completion.

The authorisation makes no link to the LTS, and it therefore appears that, legally, the activities and infrastructure of the Immediate Works and STI do not require further authorisation or EIA. However, there is a strong public perception that the EIA for the LTS will also consider the relevant activities of the STI. Since the LTS is dependent on the STI, it is recommended that the EIA for the LTS cover all the listed activities in each basin that are part of the implementation of the STI and LTS for the management of AMD.

#### b. The EIA for Long-Term Solution

It is recommended that the LTS for each of the three basins be registered as individual projects with the DEA. In this manner, localised challenges in each basin will not affect processing in the other basins.

The location of the distribution pipe system to deliver water from the treatment works to the end-users is unknown, since the details of the probable users are known only to Rand Water. It is recommended that, in any agreement with Rand Water to purchase the treated AMD, they be made responsible for all aspects of the distribution of water downstream of the treatment works, including the EIA.

i) **Central and Eastern Basins:**

The EIA should consider all existing activities (the STI) that have already been authorised and new activities that are unique to the LTS. Authorisation will only need to be sought for new activities although, as discussed, the EIA should consider all listed activities. The new activities will include all desalinisation process components and residue management and disposal facilities, as described in Study Report No. 6.

The authorisation should ideally follow an Integrated Regulatory Process (IRP), where time and cost savings are achieved and stakeholder fatigue is prevented. The work that has already been completed for the EIA of the STI should be integrated into the new EIA process.

ii) **Western Basin:**

The Pilot Treatment Plants to be implemented in the medium-term will receive water from either the Immediate Works or the Mogale Gold/Mintails TWT plant, or a combination of both. The Immediate Works are already authorised, and the necessary approvals, authorisations and licences for the Mogale Gold plant are their responsibility. However, it is important that, if the LTS is to link to the Mogale Gold plant, DWA should ensure that it is compliant with all the applicable legislation to avoid any adverse public perceptions. The Pilot Treatment Plants and the ancillary works, including infrastructure, sludge and brine disposal facilities will be the activities to be considered in the EIA.

### **13.6.2 Land and Land Rights Options and Access**

Before procurement commences, Government must ensure that all arrangements related to land and land rights (such as mineral rights, servitudes, etc.), ownership arrangements, etc., which can be described as the Land and Land Rights Access Process (LLRAP) are in place.

The land required for the LTS overlaps or adjoins that of the STI and needs to be managed as an integrated process with the STI. It is recommended that a team be established jointly between DWA and TCTA to oversee and manage the land acquisition matters of the STI and LTS.

The location of the distribution pipe system to deliver water from the treatment works to the end-users is unknown, since the details of the probable users are known only to Rand Water. It is recommended that, in any agreement with Rand Water to purchase the treated AMD, they be made responsible for all aspects of the distribution of water downstream of the treatment works, including access to land.

Ideally, there should be an integrated part of the process to obtain access to the land.

#### **a. Current Status**

The current status at the end of this Feasibility Study was:

- Relevant land portions to be addressed have been identified in Study Report No. 6; and

- Identification of the affected land portions and servitudes is complete, and adequate information is available on the ownership of land to proceed to the design stage, in which the details can be finalised and owners can be engaged.

## **b. Approach**

The proposed approach and key factors are:

- The approach and timeframes are dependent on the number of properties on which access is required, but it is likely to be a lengthy process;
- The formal process of engagement with landowners should start as soon as possible;
- Expropriation (ideally willingly) will possibly be required in certain instances;
- TCTA has been ensuring the availability of land and access to land for the STI. The LTS treatment works and associated infrastructure are adjacent to the STI sites, and there will be some overlap of owners for the STI and LTS. It is recommended that TCTA be directed to manage the LLRAP for all the sites required for the LTS.

## **c. Engagement with mines for land**

- There must be coordination with the task team addressing the liabilities of mines, since land could be offered by the mines as a contribution to offset potential liabilities; and
- The strategy for engagement with mines owning land required for the LTS must be developed as part of the initial planning. This will require support and inputs from the Department, DMR, and possibly NT.

# **13.7 Operation and Maintenance Phase**

## **13.7.1 Introduction**

The O&M Phase commences once the works are Ready for Operation (RfO). The key areas of the contract in this phase are:

- Performance of the works to deliver water to the agreed standard;
- Residue management in accordance with the contract;
- Maintenance of the works in accordance with the contract;
- Compliance with the conditions of the EIA authorisation; and
- Other important activities are:
  - Cost recovery;
  - Ensuring that all supplementary activities are on programme (monitoring, communications, etc.); and
  - Supporting the complementary activities (ingress control, mine dump rehabilitation).

The Department will retain overall responsibility in this phase, although it is recommended that they use the same IA or Contract Management team used for implementation to ensure that the conditions of the DBOM or DBOMF (PPP) contract are adhered to.

All the requirements for this phase will be described in detail in the CMP produced by the service provider and approved by the Implementer.

### 13.7.2 Operational and Performance Monitoring

The CMP will identify the institutional arrangements and protocols for the management of the contract during the services delivery or O&M stage. The formal completion of construction on the issuing of the RfO certificate will permit the commencement of service delivery and payment for treated water delivered.

The operation will be managed by the service provider, which will be responsible for:

- Abstraction of AMD from the void to maintain the TOL;
- Operation of the STI and LTS plant to treat AMD and deliver treated water of the agreed quality to the agreed delivery point;
- Maintenance of the STI and LTS infrastructure, plant and equipment over the life of the contract to the agreed standards;
- Monitoring and reporting on the quality and quantity of raw AMD, treated water, waste streams and environmental impacts or potential impacts, in relation to the agreed standards, for the duration of the contract;
- Participation in the Implementer's Contract Management team processes for managing the contract;
- Provision of access to the Implementer's Contract Management team for them to carry out their duties;
- The selling of residue products and the collection of and accounting for the revenue;
- Maintaining an asset register of all moveable and immovable project assets; and
- Collecting and holding performance data related to the LTS in a format that can be transferred to the Implementer on expiry of the contract.

The service providers' performance will be monitored by the IA and their PSP. The important areas are:

#### a. Water Delivery

The key aspects are:

- That the quality of water produced by the service provider meets the specifications; and
- That the quantities of water delivered are in accordance with the end-user agreement.

When the quality of the water is not according to specification, it is important that it is not supplied to the end-user, but recycled for re-treatment.

Record-keeping must be in accordance with the approved Management Plan.

## **b. Residue Management**

The key aspects are:

- Ensuring compliance with the contract conditions;
- Ensuring compliance with the conditions of the EIA Authorisation; and
- Ensuring that there is always adequate capacity.

It will also be important to monitor any contracts into which the service provider enters for the sale of residue products.

## **c. Maintenance of the Works**

Maintenance of the works, as specified in the contract and to the required standards, is essential for operating the works, and especially for ensuring the expected residual value at the end of the service providers' contract.

The service provider will also be responsible for:

- An annual maintenance and lifecycle plan that will:
  - Review maintenance performance for the past 12 months;
  - Review maintenance performance for the contract period to date;
  - Forecast, with cash flows and a commentary, the planned maintenance and lifecycle replacement for the next 12 months;
  - Forecast with cash flows and a commentary, the planned maintenance and lifecycle replacement for the remainder of the contract period; and
  - Identify any lifecycle risks that may exist and that could materialise within the remainder of the contract or thereafter.

## **d. Compliance with the EIA**

The EIA Authorisation will have been granted to the Department. They will thus be responsible for ensuring that all the conditions are met.

## **e. Cost Recovery**

The Department will commit itself to certain cost-recovery targets when making funding arrangements. These must be monitored and reviewed on an on-going basis.

- Assisting with the dilapidation survey carried out towards the expiry of the contract; and
- About 3 years prior to the expiry of the contract, assisting the Implementer's Contract Manager with contract expiry activities and possible handover to another Service Provider.

The Implementer and Service Provider might appoint an Independent Monitor to provide an independent review of the service delivery performance of the Service Provider.

## 13.8 Organisational Structure for Implementation

### a. Institutional Mandates and Capacity - Department of Water Affairs (DWA)

The Minister of Water and Environmental Affairs must ensure that water is, inter alia, protected, used and controlled in a sustainable manner, while upholding and promoting environmental values.

In terms of the NWA (36:1998), the Department is the trustee of the water resources of the country. As such, it has authority over, and responsibility for, the sustainable use and protection of the water resources.

The Department has overall responsibility for implementing the management of AMD, as agreed by the IMC. The Department reports directly to the IMC and also to the IGTT which the Department chairs. The Department will need to establish formal agreements with the other public and private entities that will need to work together under the leadership of the IMC and the Department to achieve effective implementation.

The Department, through its National Water Resource Infrastructure Branch (NWRIB), is responsible for the establishment, as well as O&M, of national water resources infrastructure. The AMD works will be part of this infrastructure, but the implementation of a DBOM project will be a first for the Department and will require skills that are not currently available in the Department.

The Regional Offices of the Department used to perform a regulatory function, as well as being responsible for the O&M of GWWs. These functions have lately been separated, and the operation of GWW is now the responsibility of NWRIB, with the regulatory function being retained by the Regional Office. However, the Regional Office has played a major role in the implementation of the STI.

The capacity of DWA's Head Office and Regional Offices is insufficient to fulfil its responsibilities for infrastructure development, and extensive use is made of TCTA and PSPs to support it.

DWA administers the Vaal River Tariff (VRT), which includes:

- Determining the tariff;
- Monitoring the water use;
- Invoicing users;
- Collecting the revenue; and
- Distributing funds to various accounts or agencies that are due to receive funding.

**b. Department of Mineral Resources (DMR)**

DMR performs a regulatory role in the mining sector and needs to be involved in the implementation of AMD works in order to ensure that the required regulatory conditions are met.

The CGS, which is carrying out various important studies and implementing ingress control measures, is responsible to the DMR.

**c. Department of Environment Affairs (DEA)**

The DEA has the mandate to ensure that both NEMA (107:1998) and NEM:WA (59:2008) are adhered to.

They retain direct responsibility for projects implemented by National Government Departments and will be responsible for the Environmental Authorisation of the LTS.

**d. Trans-Caledon Tunnel Authority (TCTA)**

TCTA was established in 1996 in terms of the treaty to implement Phase I of the LHWP. They were responsible for implementing the infrastructure in South Africa and procuring and managing the funding for the entire water transfer infrastructure on behalf of South Africa.

Subsequently, the Department has utilised TCTA to manage the implementation of large bulk water transfer and supply infrastructure projects. TCTA not only performs the project management technical supervision and land procurement functions, but also arranges Private Sector loans and negotiates agreements with the end-users of the water, on behalf of the Department.

TCTA is well structured to take responsibility for implementing bulk water projects, which has been its core business since its establishment.

TCTA is currently implementing the Immediate Works and the STI in terms of a Directive from the Minister of Water and Environment Affairs and supplementary directives (authorisations) from the Department to discharge water and dispose of waste. TCTA has not previously been responsible for operating projects, but will be responsible for the operation of the STI until the LTS is commissioned.

TCTA will require a directive from the Minister of Water and Environment Affairs in order to undertake the implementation of the LTS on behalf of the Department.

The implementation of a DBOM project will be a first for TCTA, and they will require additional in-house skills and resources to manage the PSPs that they will appoint to prepare the contract documentation and supervise the works.



## **e. Water Boards**

### **i) Rand Water:**

Rand Water, a Water Board in terms of the WSA (108:1997), is responsible for abstracting water from the Vaal River System, treating it to potable standards and supplying, either directly, or indirectly via local authorities, mines, industrial and domestic users.

Traditionally, Rand Water has supplied potable water on the basis of the abstraction of raw water from the Vaal Dam, and treating and distributing it to bulk users and municipalities. Rand Water has indicated that they wish to purchase treated AMD and supply it to industrial water users.

Rand Water should urgently be engaged to establish a MoU and then an agreement between the Department and Rand Water in terms of which they receive and pay for the treated AMD and make all the necessary arrangements to distribute the water from the LTS treatment works to their users.

Arrangements also need to be agreed with Rand Water for them to have an appropriate oversight role during implementation to enable Rand Water to have confidence in the quality of water being supplied from the AMD treatment works.

### **ii) Magalies Water:**

Magalies Water's area of jurisdiction is close to the Western Basin, and they could be a purchaser of the treated water in that basin. However, the preference is to supply Rand Water so that the AMD replaces water from the Vaal River System.

## **f. Local Authorities / Water Service Authorities**

All LAs should do whatever is required of them to facilitate the implementation of the STI and LTS for AMD. The following LAs have responsibilities in the three mining basins where the LTS will be implemented:

- Western Basin: Mogale City Metropolitan Municipality; Randfontein Local Authority
- Central Basin: Johannesburg Metropolitan Municipality
- Eastern Basin: Johannesburg Metropolitan Municipality; Ekurhuleni Metropolitan Municipality

LAs have the following responsibilities that they must exercise in the implementation of the LTS:

- land use zoning;
- urban stormwater management;
- approval of traffic planning; and
- compliance with building regulations.



LAs are also responsible for significant water and waste water infrastructure. It is estimated in the WRC's Report **"The State of Non-Revenue Water in South Africa"** (WRC, 2012) that the non-revenue water of which about 70% in physical losses in the Metropolitan Municipalities is about 35% and that the losses from the municipal water networks are between 20 and 30%. Leaks from sewer networks have not been quantified. Both networks are possible sources of ingress into the mine voids, which should be reduced as far as possible.

### 13.8.1 DWA's Responsibilities and Organisational Requirements

#### a. DWA Responsibilities

The Department has overall responsibility for ensuring the successful implementation of the STI and LTS, as well as numerous associated activities for the effective management of AMD.

The immediate actions to be taken by the Department are listed below, while their subsequent responsibilities are listed in the next section.

- Establishing contractual arrangements for implementation (e.g. Directives to TCTA or other Public Sector Agency);
- Procurement of Funding;
- Obtaining NT approval of the Feasibility Study; and
- Issuing a Directive to a Public Sector Agency to implement a DBOM contract for the LTS in the Central and Eastern Basins.

#### b. DWA Organisational Requirements

Even if, as anticipated, the procurement process for the Central and Eastern Basins DBOM contracts is run by an IA, the oversight of the procurement and ensuring timeous execution of the many other recommended initiatives will require a strong management team in DWA. They will be required to oversee the procurement process through to completion, including those contract procurement processes, delivery of the infrastructure through the construction and commissioning stage for each basin, and the monitoring of performance and management of contracts during the operational stage.

It is recommended that the Department now establish a dedicated SPU to manage the implementation of the LTS for AMD and coordinate all the other activities required for the effective long-term management of AMD in the Witwatersrand. DWA's NWRIB is responsible for implementing infrastructure projects, such as the LTS for AMD, and the SPU should be established and resourced by the NWRIB. The dedicated project unit should be responsible for:

- Ensuring that it has adequate resources, including specialist PSPs, to enable it to timeously fulfil all its responsibilities;
- Ensuring that adequate funding is available before contracts are concluded;

- Preparing and concluding an end-user agreement with Rand Water;
- Ensuring that agreements for access to the required land are concluded timeously;
- Overseeing and participating in the execution of an EIA for the LTS works in the Central and Eastern Basins and for the proposed Pilot Treatment Plants and ancillary works in the Western Basin. The Department will be the applicant for the EIA;
- Overseeing all procurement, implementation and operational activities, including performance monitoring undertaken by the IA, which is likely to comprise a DBOM contract for implementing the LTS in the Central and Eastern Basins, at an estimated capital cost of about R 2.1 billion and R 2.6 billion respectively;
- Managing the process for establishing Pilot Treatment Plants and constructing ancillary works in the Western Basin, at an estimated capital cost of R 1.3 billion;
- Managing the income stream from sources such as the VRT, WDCS and a possible future Environmental Levy;
- Leading negotiations with mines to secure their contribution to the capital and operating costs of the solution to AMD;
- Concluding agreements on the contribution to be paid by the Private Sector (mines, GRMC, etc.), which may wish the static water levels to be maintained below that required to protect the environment. TCTA already has an agreement with one mine in the Central Basin;
- Ensuring that DWA timeously fulfils its regulatory functions in terms of the NWA (36:1998), including water use licences and discharge approvals, etc.;
- Coordinating the expanded water quality and quantity monitoring programmes for surface and underground water resources and participating in the assessment of the results;
- Coordinating a pro-active communication strategy on all initiatives to manage underground AMD in the three basins and elsewhere to maintain and improve the Department's positive profile with the stakeholders and public. This should link to/support the communication strategy for implementing the Vaal River Strategies;
- Coordinating/participating in the implementation of all measures to reduce ingress to the mine void; and
- Determining the preferred sources of income (cost recovery mechanisms) to Government and overseeing implementation of the agreed tariffs and charges.

### **c. Supporting Directorates**

#### **(i) Regional Offices:**

The Regional Offices of DWA will be responsible for the Department's regulatory activities, including authorisations, licences and compliance monitoring. Regular monitoring of implementation and operation will be required to ensure that the authorisation conditions, etc., are met.

(ii) **Integrated Water Resource Planning:**

The Chief Directorate Integrated Water Resource Planning (IWRP) can provide the continuity required in the approach to AMD and could be responsible for the Department's role in the Pilot Treatment Plant project in the Western Basin, as well as for other follow-up investigations. It should also participate in regular reviews of the results of the evaluation of all the surface and sub-surface monitoring results, as well as the water quantity and quality data from operating the abstraction works. This information would inform the Vaal River System strategies and other DWA strategies.

### **13.8.2 Proposals for DWA to secure adequate resources**

The Department does not have the in-house management capacity or sufficient in-house expertise to support the dedicated project unit in executing all its responsibilities. In particular, the Department will require support and additional capacity for the implementation of procurement and for monitoring the operational performance of a project of this magnitude and complexity.

#### **a. Implementing Agent**

Since DWA has decided to implement a DBOM contract and not a DBOMF (PPP) contract, it is recommended that a Public Entity with appropriate experience and capacity be directed to act as the IA on behalf of the Department. Rand Water and TCTA appear to be the main contenders.

#### **b. Professional Service Providers**

It is recommended that the SPU appoint a PSP team for support in fulfilling its responsibilities as soon as possible. It will need to be a multi-disciplinary team, with project management, technical, financial, legal and contract expertise.

In addition, PSPs will be required as Transaction Advisors, to be appointed by the IA for procurement and as the independent Environmental Practitioners to conduct the EIAs. A PSP may also be required to assist TCTA with the LLRAP, but this could be done by the PSP for the STI.

### **13.8.3 Summary of Priority Actions**

The following are the priority actions for the Department to establish and resource the required organisational structure.

- Agree on institutional arrangements and responsibilities;
- Establish a SPU and define its responsibilities;
- Decide on the form of contract to be used, whether DBOM or DBOMF (PPP);
- Appoint the Head of the SPU;
- Issue Directives to Public Sector Agencies; and
- Appointment of a PSP team to support the SPU.

## 13.9 Implementation Programme

The key implementation dates for the procurement of a DBOM are shown in **Table 13.1**.

**Table 13.1: Implementation programme - DBOM procurement**

Component	Activity completion dates	
	Central Basin	Eastern Basin
<b>Transaction Advisor Mobilised</b>	March 2014	April 2014
<b>RFQ Issued</b>	May 2014	June 2014
<b>RFP Issued</b>	October 2014	October 2014
<b>Proposals received</b>	April 2015	April 2015
<b>Evaluation complete</b>	June 2015	June 2015
<b>Negotiations commence</b>	July 2015	July 2015
<b>Financial closure</b>	April 2016	April 2016
<b>EIA consultant appointed</b>	April 2014	April 2014
<b>Authority review of EIA</b>	March 2016	March 2016
<b>Detail design commences</b>	April 2016	April 2016
<b>Construction commences</b>	May 2016	May 2016
<b>Desalination works commissioned</b>	August 2017	January 2018

### 13.9.1 Assumptions

The detailed implementation programme is based on the following assumptions:

- The Department will establish a SPU to be responsible for all the activities required for implementation of the LTS to address AMD. The SPU should also coordinate the supplementary activities;
- The SPU will appoint a PSP to assist in fulfilling their responsibilities and their coordination role;
- The Department has advised that they will use a DBOM contract and not the PSC or DBOMF alternatives; and
- The Department have advised that they will direct a Public Sector Agency to be the Implementing Agent for the procurement of the DBOM contract. They have also advised that they will direct TCTA to carry out the EIA and procure the land for the LTS.

### 13.9.2 Critical Activities

#### a. All Three Basins

- For all three basins, the critical activities are:
  - The Department approving this Feasibility Study;

- The Department deciding on its internal organisational structure and responsibilities for implementation;
- The Department establishing the SPU;
- The Department deciding on the funding and cost-recovery plans.
- The Department submitting the Feasibility Study with their organisational structure for implementation, and the funding and cost-recovery plan, to NT;
- NT agreeing the funding and cost recovery plans;
- The Department issuing directives to a Public Sector Agency to:
  - Procure a DBOM contract for the implementation of the LTS in the Central and Eastern Basins;
- The Department issuing directives to TCTA to:
  - Procure the land required for the LTS; and
  - Carry out the required EIA.
- The Department concluding a Memorandum of Understanding (MoU) with Rand Water in terms of which they will buy the treated water at the treatment works.

If started timeously, the EIA can be completed, in parallel with the procurement process, with authorisation being received before financial close.

## **b. Western Basin**

The detailed arrangements for implementation are dependent on the results of on-going assessment of the Mintails proposal for neutralisation, which is currently being assessed by TCTA.

Although the programme is based on the assumption that the Mintails TWT process will be used, it does not imply any preference for that option. The decision must be based on the assessment of the technical merits and regulatory requirements.

The critical activities are:

- Establishing an agreement between the Department, WRC and the DST defining the roles and responsibilities for the procurement of Pilot Treatment Plant;
- Appointment of a PSP, either by a Public Sector Agency or the Department, to prepare design and tender documents for the ancillary works, including the SSFs and brine disposal; and
- Initiating an EIA for the works in the Western Basin.

In the Western Basin, a new implementation process will need to be started timeously to ensure continuity of treatment after the Pilot Treatment Plants. It is recommended that the Pilot Treatment Plants should be required to operate for at least 5 years to allow time for the pilot technologies to be proved and then operated for 2 years before commencement of a

new procurement process, which will take at least 3 years before new infrastructure is commissioned.

### **c. Central Basin and Eastern Basins**

Once the institutional contractual and funding arrangements have been agreed, the critical activities are those leading to the procurement of the LTS, starting with the appointment of the Transaction Advisor. The Department has advised that they intend to direct a Public Sector Agency to be the IA, and if procurement proceeds as shown on the programme, the EIA is not on the critical path, but the EIA will be critical if there are any delays in its completion.

The LTS in the Central Basin can be Ready for Operation (RfO) in August 2017 and the LTS for the Eastern Basin RfO by January 2018.

## **13.10 Evaluation of Impacts and Benefits of the Implementation**

The STI and LTS are being implemented to achieve the objectives of:

- Protecting the ECLs and/or SECLs; and
- Limiting the impact of the solutions on the environment.

There are a number of unknowns that affect implementation, including:

- Whether the ECLs/SECLs can be raised, thereby saving costs while still protecting the environment and socio-economic assets, or whether they must be lowered to achieve the objective;
- How the water quality of the water abstracted from the void will change over time;
- How the water level in the void will vary across each basin; and
- The volume of water that will have to be pumped to maintain the applicable TOLs and whether the proposed TOLs are far enough below the ECL/SECL to protect these levels.

Intensive monitoring is critical for the on-going effective management of AMD as this is discussed in Section 14.2. The monitoring of the re-watering process of the basins is a long-term commitment and requires inter-governmental collaboration, good coordination and management, together with support from mining and other private partners.

The proposed monitoring programme will provide information that will enable the unknowns to be evaluated. That information, together with operational information from the STI and LTS, must be assessed and evaluated with the objective of making regular recommendations for refined operating procedures or monitoring.

The effective management of the three mine basins requires a dedicated team to assess all the monitoring information:

- Hydrological;
- Hydrogeological;

- Voids; and
- Aquifers;
- Operational data.

This is required to ensure the effectiveness of the STI and LTS and plan further interventions and adjustments to the operations. This can only be achieved if a team, which has sufficient knowledge and resources to support integration between water resources managers and well-maintained databases, is tasked with this work. There will be considerable interaction with the IA and they could be tasked with these responsibilities.

The Wits AMD Hydrological Monitoring Committee (HMC) is currently responsible for hydrological monitoring in the three basins. It consists of officials from the DMR (including the CGS), The Department (including TCTA), DST (including the Council for Scientific and Industrial Research (CSIR)) and LAs (Mogale City Local Municipality).

The Department or if so directed, the Public Sector Agency directed to be the IA, should appoint a PSP, which could be the PSP appointed to implement the LTS, to set up the required systems and carry out the assessment and evaluations for at least the next 5 years to allow time for the effects of the LTS to be evaluated. On-going assessments will be required after 5 years, but at a reduced level of activity. The study results will inform the on-going DWA initiatives in the Vaal and Crocodile (West) River Systems.

The Study should also include on-going monitoring of the operating costs of the STI and LTS as the volumes and water quality change. This will inform future procurement processes.

### **13.11 Preparing for Subsequent Implementation**

Planning the second phase contracts will require inputs from the evaluation of the STI and medium-term works, as well as the O&M experience gained.

The lessons learnt must be carefully documented to guide the preparation of new tender documents. Of particular importance will be changes in the quantity and quality of the water being abstracted and produced in each step of the treatment process.

The condition of the assets at the end of the Implementer's contract will have a significant effect on the cost of the subsequent phase. The Service Provider will be required to maintain an asset register and this will be used in the next phase of implementation.

Technology developments must be monitored throughout the O&M period so that appropriate procurement documents are prepared and cost effective contracts are procured.





## **14. OTHER REQUIREMENTS FOR SUCCESSFUL MANAGEMENT OF AMD**

### **14.1 Introduction**

The previous chapter described the strategy for implementing the physical works for the LTS. However, those actions on their own will not ensure the successful management of AMD on the Witwatersrand and several other initiatives are essential to complement the physical works. An effective programme of hydrological and hydrogeological monitoring is essential to guide the operation of the integrated STI and LTS, and guide future actions. Equally important is the assessment of the information as discussed in Section 13.10.

Assessing the risk of dolomite instability in the Western Basin is also a very important part of the solution.

It is also very important that the public is kept well informed of all the activities that are being undertaken and the progress being made. The public should also be encouraged to provide any information they have and could provide useful information to support the monitoring programme.

The decant of untreated AMD in the Western Basin since 2002 has severely impacted the Tweelopies Spruit. Previous discharge of AMD from the Central and Eastern Basins and the future discharge of neutralised AMD from the STI for these basins will impact the receiving rivers. These impacts should be assessed and appropriate remediation implemented.

While the implementation strategy and complementary activities will provide a solution for managing the underground AMD, it will cost considerably more than necessary if the supplementary activity of reducing ingress is not carried out as quickly as possible. Significant pollution from AMD also comes from the runoff and leachate from mine dumps. Any initiatives to reprocess and rehabilitate these areas, which will also reduce ingress, should be supported.

These complementary and supplementary activities are discussed in the following sections. However, AMD is not confined to the Western, Central and Eastern Basins of the Witwatersrand, but occurs in the other gold mining areas and coal mining has caused extensive AMD pollution. A National Strategy for managing AMD is proposed. Lessons learnt from this Study that can support that are also discussed.

### **14.2 Hydrological and Hydrogeological Monitoring**

#### **14.2.1 Introduction, Principles and Objectives**

The successful management of AMD in the mine voids of the three mine basins, in order to protect the environment and socio-economic assets at minimum cost, requires a dedicated, comprehensive and integrated monitoring and assessment programme. This can only be

achieved by sustaining and expanding the programme and capacity of the Wits AMD Hydrological Monitoring Committee (HMC) to support integration between water resource managers and well-maintained databases. The detailed proposals are described in Study Report No. 8.

This is a long-term commitment and requires inter-Departmental collaboration, and good coordination and management, together with support from mining and other private partners that carry out monitoring.

Real-time hydrological and hydrogeological data are vital, and on-going management of monitoring requires a controlling body such as the Wits AMD HMC, which is currently responsible for hydrological monitoring in the three basins. It consists of officials from the DMR (including the CGS), the Department (including TCTA), DST (including the CSIR) and LAs (Mogale City Local Municipality).

Three major aspects that should be monitored are mine void water, near-surface aquifers and surface water. The quality and quantity of each should be monitored.

The objectives of the hydrogeological and hydrological monitoring of the mine void are to:

- Assess whether the implementation of the STI and LTS are achieving their objectives;
- Identify trends in water quality that may influence decision-making;
- Provide early warning of possible problems and identify areas where new interventions are required for effective management of the AMD in the mine voids;
- Provide data to assist in assessing the effectiveness of the ingress control measures that have been implemented; and
- Refine current understanding of the response of the void water to rainfall.

Monitoring of surface water and near-surface aquifers (groundwater) is required so that the reasons for any changes in the quantity and quality of surface and groundwater can be understood and, if necessary, any problems can be addressed as the implementation of the STI and LTS proceeds. In basins where the ECL determines the TOL, monitoring is essential to assess any impacts of the void water on the groundwater and allow the ECL to be optimised.

Monitoring is especially necessary during the initial phases of pumping so as to establish the hydrogeological parameters of the void. On-going monitoring is necessary to provide information on changes in connectivity of the compartments, for example due to collapse in the void.

Adequate spatial distribution of rainfall stations is required to correlate rainfall with ingress. The current South African Weather Services' coverage will need to be extended, and the stations should be real-time units.

The monitoring recommendations for each aspect are summarised in the following sub-sections. Detailed recommendations for monitoring are given in Study Report No. 8.

## **14.2.2 Hydrogeological Monitoring of the Mine Void**

### **a. Rationale**

Sufficient water level monitoring points are required to understand the hydraulic gradient across all the connected compartments of each basin, and to monitor the water level in isolated compartments. Only the water level is being monitored at present, although CGS has previously used a PSP to do water quality profiling to about 3 000 m below surface in the Central Basin. Water quality monitoring should be implemented in all three basins as soon as practical.

A water quality profile of the mine voids is vital for long-term planning and management of the void water. It could influence the operations, effectiveness of the water treatment facility and selection of additional abstraction points, and may enable more cost-effective management of the pumping and treatment operations.

### **b. Western Basin**

Four shafts, covering the northern portion of the mine void, are currently being monitored by DWA. It is suggested that an additional shaft further south and a shaft in the centre of the basin be added in the monitoring programme to provide better understanding of the connectivity in the basin.

### **c. Central Basin**

The number of shafts being monitored at present is adequate to achieve the required objectives, but the situation should be regularly reviewed, particularly if the aquifer or surface water monitoring indicates unexpected conditions.

It is likely that some isolated compartments are filling independently of the main void. It is suggested that the mine plans be examined to locate such compartments and that monitoring points be introduced at those locations.

### **d. Eastern Basin**

The Department is monitoring water levels in five shafts, and plans to monitor four additional shafts.

The shafts for which data are currently available indicate that the water level across the basin varies substantially and that there are apparently several isolated compartments. Data from the proposed additional shafts are therefore required as soon as possible to assess inter-connectivity across the basin and the behaviour of the isolated compartments.

In addition to the Grootvlei No. 3 Shaft in the main compartment, from which AMD will be pumped, and the other shafts which have been selected for monitoring by the Department, it

is recommended that one shaft on one of the mines to the north-west of Grootvlei (New Modder, Government Gold Mining Areas, New State Areas or Geduld) be monitored so that the hydraulic grade line and the appropriateness of the TOL can be assessed.

### **14.2.3 Near-surface Aquifers**

#### **a. Rationale**

The near-surface aquifers that are vulnerable to pollution are those situated over the void where the base of the aquifer is closest to the ECL. Monitoring in these areas is thus the highest priority. Across all three basins, the near-surface aquifer in the vicinity of the mine tailings facilities has been severely polluted by plumes emanating from these dumps. This pollution is unrelated to the mine void water, and a baseline of aquifer water quality is required, before the water in the voids reaches the TOL associated with ECLs, to help identify the sources of pollution.

It is recommended that a hydro-census be undertaken of all the existing boreholes within areas where the void is closest to surface in order to identify those that have been, or can be, monitored specifically for this purpose (i.e. that have sufficient depth and are at a satisfactory location). The census will also identify locations where new dedicated boreholes can be drilled, taking care not to intersect the mine workings.

The monitoring of these boreholes should include water levels, as well as groundwater quality in terms of pH, EC, TDS and heavy metals. The water quality sampling should be undertaken at least quarterly to establish baseline water quality data, but the water levels should be monitored more frequently to establish the seasonal variations. Once the mine void water reaches the proposed TOL associated with the ECL (as opposed to the SECL) in each basin, monitoring should be increased to monthly for at least a year to ensure that there is no pollution of the shallow aquifer. Thereafter, if there is no deterioration in the water quality, monitoring could be reduced to quarterly if the ECL is not being raised.

#### **b. Western Basin**

Mining on the West Rand is overlain by fractured aquifer that has been polluted by mine tailings facilities. The major concern with respect to groundwater and shallow aquifer contamination in the Western Basin is the dolomitic outlier underlying the Tweelopies Spruit to the north-west of the mines. The ingress of void water into this aquifer has resulted in complete saturation, and the AMD has, until recently, been decanting via numerous springs in the Tweelopies Spruit, which discharges downstream across the Witwatersrand quartzites. Pollution of the Tweelopies Spruit can then cause pollution of the Zwartkrans Dolomitic compartment in the Cradle of Humankind.

It is recommended that at least five monitoring boreholes be established in the dolomitic outlier along the Tweelopies Spruit in order to monitor the changes in this aquifer associated with dewatering of the mine void. It is important to monitor these changes, as pollution in the Tweelopies Spruit also emanates from the tailings dumps in the catchment.

### **c. Central Basin**

Mining in the Central Basin is overlain by a fractured aquifer, which is utilised through numerous boreholes. There are no major abstraction points located in the Witwatersrand Supergroup rocks in this area, but there is significant abstraction from the dolomitic aquifer to the south that overlies the Witwatersrand Supergroup. This aquifer lies well to the south of the mine void and is unlikely to be directly polluted by void water, although it is already severely polluted from mine tailings facilities. DWA has adequate ground water quality monitoring points in this dolomitic aquifer.

The critical area for monitoring the effect of mine void water on the shallow groundwater aquifer is in the area of ERPM mine, where the surface elevation is at its lowest. There are currently no monitoring boreholes in this area. The location of monitoring boreholes will have to be chosen with care, because the near-surface aquifer in the area is probably severely polluted by plumes emanating from the many mine tailings facilities in the area.

### **d. Eastern Basin**

Two major aquifers (fractured Karoo Super Group and Chuniespoort Group dolomites) occur within the mine boundaries of the Eastern Basin. There is extensive pollution of the near-surface aquifer along the Blesbokspruit as a result of plumes from the tailings facilities and discharge of neutralised water from the mine void in the past. As in the other basins, great care must be taken to distinguish between pollution directly from the mine void and pollution from surface sources.

Monitoring should be done in the vicinity of the Blesbokspruit where the surface elevation is at its lowest and groundwater is at surface or very shallow. It is recommended that 8 monitoring boreholes be established.

## **14.2.4 Surface Water**

### **a. Rationale**

Expansion of monitoring of the flows and quality of the water in streams that have been, and could be, affected by decanting AMD is recommended to enable the Department to understand the situation and present the facts to stakeholders. The Department and Rand Water (in the Central and Eastern Basins) have extensive water quality monitoring programmes in the affected areas, but flow monitoring is sparse. The majority of streams draining the basins are polluted by effluent from tailings facilities, as well as municipal sources. Therefore, quite detailed spatial knowledge of both flow and quality are essential for determining the effect of underground AMD and comprehending the relative load contributions from various sources.

## **b. Western Basin**

The planning and construction of three surface water gauging stations down the Tweelopies Spruit is included in the current work by TCTA. It is recommended that an additional monitoring site be established to the north of the dolomitic outlier where the Tweelopies Spruit crosses the Witwatersrand quartzites.

An additional weir would also need to be installed at the source of the Wonderfonteinspruit, upstream of the mine dumps, in order to get baseline quality samples. Where the Wonderfonteinspruit traverses the Witpoortjie fault, it is recommended that the two existing weirs be monitored for flow and sampled for water quality in order to estimate whether there is water ingress into the mine void via the fault.

## **c. Central Basin**

Within the Central Basin, streams originate in the Witwatersrand ridges of the West Rand Group and drain southwards in the Vaal River System.

Surface monitoring of flow and water quality should be undertaken at weirs C2H230 and C2H231 to monitor flow rates in the Natalspruit and Elsburgspruit. The data can assist in confirming whether there is contamination of AMD into the shallow aquifer, which serves as base flow for the Natalspruit and Elsburgspruit. C2H226 (located on a tributary of the Klipspruit) and C2H041 (located on the Klip River) should be similarly monitored, as they are located in another area where pollution could occur.

## **d. Eastern Basin**

The northern and eastern portions of the Eastern Basin are drained primarily by the Blesbokspruit, while the Rietspruit drains the central and western portions.

The following weirs are recommended for flow and water quality monitoring:

- C2H200 and C2H134 are located upstream and downstream respectively of Cowles Dam, and monitoring these weirs will help in determining the ingress from Cowles Dam; and
- C2H150 is located upstream of the Grootvlei No. 3 pumping shaft, and monitoring this weir will indicate flow and baseline water quality prior to discharge of effluent from the treatment plants.

## **14.3 Assessing the Dolomitic Stability Risk in the Western Basin**

The main risk to the dolomites associated with the abstraction of the AMD is the potential instability caused when the dolomites are dewatered. This will only occur in the Western Basin.

The dolomitic compartment underlying the upper Tweelopies Spruit will be substantially dewatered by the pumping in the Western Basin. There is therefore a very high risk of instability (sinkholes or dolines) in this area.

The most significant and only infrastructure that is not related to mining is public roads.

It is recommended that gravimetric surveys be undertaken along all the roads in the area that is likely to be affected. Where this survey indicates potential subsidence, percussion drilling is recommended to confirm the extent of the areas at risk.

Once the areas of risk have been identified, precautions can be taken and on-going monitoring of these areas established.

## 14.4 Key Stakeholder Engagement and Communication

AMD management is a complex and multifaceted challenge requiring inputs from a wide range of stakeholders to ensure a sustainable LTS. Effective engagement and communication with stakeholders and the public is a key component of managing AMD.

Effective communication with key stakeholders during the Feasibility Study has done much to improve public confidence in Government's management of AMD in the Witwatersrand. It is critical that effective communications to the key stakeholders and the public are continued during the Implementation and Operating Phases.

The LTS to address the AMD originating from the mine voids is only one of several parallel initiatives to address the AMD challenge. The public have received information about these initiatives in a fragmented, uncoordinated manner, leading to stakeholder confusion, mistrust, fear and lack of confidence in Government's efforts.

It is recommended that the Department:

- Develop an overarching and coordinated communication strategy; and
- Embark on a separate strong public relations/awareness-raising drive, in addition to the EIA, to change current negative perceptions and address the capacity-building issues related to communication about AMD.

The strategy for the future should, on a regular basis:

- Engage key stakeholders (academics, technical specialists, representatives of interest groups and relevant authorities), including those involved in parallel initiatives, to harness the collective wisdom towards finding an LTS to the AMD challenge; and
- Communicate sufficient and correct information to raise public awareness of the initiatives that are under way, their progress and benefits. This should reassure the general public that Government's efforts to manage AMD are on programme and effective.

The key messages to be communicated are summarised as:

- The AMD challenge across all mining areas;
- Government's on-going commitment to resolve the AMD issues in a strategic and coordinated manner;



- The results of managing AMD in the context of Vaal River water quality management strategies;
- Risk management plans that have been developed on their effectiveness;
- Activities aimed at the protection of public interest;
- Results of the hydrogeological monitoring, including mine void water levels;
- The use of the water;
- Lessons being learnt about treatment technologies; and
- All other initiatives.

If this strategy is implemented, it will give the public a lot of confidence in the Department and the actions it is taking, as well as to bring together the combined knowledge of those working in the sector.

## **14.5 Rehabilitation of Rivers**

### **14.5.1 Background**

Mining has had numerous impacts on the environment and largely uncontrolled mine closure has led to the present situation minimise these impacts in the Western, Central and Eastern Basins. As described in the Preface, AMD with various levels of treatment, and thus various qualities, has been discharged into the rivers downstream of all 3 basins for many years.

As rehabilitation forms part of the holistic management of urban rivers, the proposals in this section should be considered in the context of existing river and wetland management plans for the systems affected by AMD. This includes, for example, the Ramsar Blesbokspruit Wetland Management Plan that has recently been developed by the DEA, and other Provincial and Local Government initiatives.

The rehabilitation of rivers affected by AMD will take place in terms of source controls and various mitigation measures. Source controls will be addressed through the combination of the STI and LTS through which water discharged to the environment will be treated to acceptable and sustainable qualities.

Although the STI has resulted in improved water quality in the Western Basin now that decant of raw AMD has been stopped, the current discharge of neutralised AMD with elevated salt levels is still causing impacts for which mitigation will have to be considered, once the desalination through the LTS is in place. Although the rivers in the Central and Eastern Basins have not recently been subject to the discharge of raw AMD, they will receive neutralised but saline water from the STI, until the LTS is commissioned.

In addition to the water quality impacts, increased volumes associated with discharge have affected the systems in the three basins, especially in the Tweelopies Spruit, which was a non-perennial system under natural conditions.



## 14.5.2 Approach

The general approach to rehabilitation is described in the following paragraphs. Such rehabilitation will require authorisation in terms of NEMA (107:1998) and the NWA (36:1998), and will therefore be done in the context of Integrated Environmental Management, which would allow for scoping, baseline assessment, recommendation of options, environmental approvals, implementation and monitoring.

### Step 1: Scoping

Assessment of the existing availability of information, monitoring programmes and identification of stakeholders.

### Step 2: Baseline Assessment

Dedicated ecological baseline assessment of the system, to include the full range of aquatic, water quality, hydrological, riparian and terrestrial habitat assessment associated with the system now that the STI is in place. This should be carried out at least once in summer and once in winter. It should be carried out by a multi-disciplinary team of experts, and include at least:

- Present Ecological State (PES) assessment of the system, including the full range of drivers and responses;
- Assessment of the remaining pollution sources, such as old tailings or waste rock dumps, as well as dysfunctional sewage WWTWs and their contributions to/effects on the ecological integrity of the rivers;
- Engaging riparian stakeholders;
- Assessment of the impacted area (i.e. how far downstream the effects are visible);
- Assessment of the impacts caused, the likelihood of natural rehabilitation and the time frame for such rehabilitation; and
- Assessment of the fate of the “yellow boy” nodules, which have been generated from the crust which formed during since decant and which have broken off the crust since neutralisation.

### Step 3: Recommendation of options

Recommend proven rehabilitation options with related costs, and proposed phasing. The recommendations are likely to include:

- Removal of the precipitation layer on a river bed and banks;
- Bank stability and resilience against high flow or flood events;
- Riparian vegetation rehabilitation; and
- Cost–benefit analysis of proposed rehabilitation actions.

#### **Step 4: Obtain environmental approvals**

Obtaining the environmental approvals required to effect the work (as working in the floodline is an activity listed in the NWA (36:1998) and NEMA (107:1998)). The NWA (36:1998) Section 21(c) and (i) General Authorisations for rehabilitation activities should be considered in terms of their applicability.

#### **Step 5: Implementation**

Procurement of a rehabilitation contractor to conduct the necessary work.

#### **Step 6: Monitoring and evaluation**

A monitoring plan to assess the effectiveness of the operations will be required. It will be important to select suitable indicators of rehabilitation for monitoring, which may for instance include monitoring trends in diatomics, macro-invertebrates, water quality and fish, in order to make comparisons with the baseline monitoring. It is recommended that the results include, but are not limited to, interpretation in terms of changes in the PES of the system. There may be opportunities to align with existing monitoring programmes

Monitoring and reporting on the effectiveness of rehabilitation, including communication with stakeholder and the public.

### **14.5.3 Western Basin**

The focus will be on the reparation of the effects of past uncontrolled AMD decant, and the current effects of saline discharges by the STI.

Rehabilitation of the Tweelopies Spruit in the Western Basin is required due to the following:

- Decanting and discharge of a mixture of partially treated and untreated AMD into the Tweelopies Spruit from 2002 until 2012 (10 years of AMD flow); and
- The application of lime to neutralise the acidity of the water, which caused the precipitation of Iron (III) hydroxide and other metal precipitates commonly known as “yellow boy” in the Tweelopies Spruit, causing an uninhabitable crust to form.

This has resulted in:

- Habitat destruction and alteration of the physical system;
- Loss/reduction of essential elements of the habitat required for continued biological function (e.g. O<sub>2</sub> depletion); and
- Destruction of macroscopic life through the presence of toxic elements.

Only recently, with the implementation of the immediate source control measures, has life started to return to this system.

## **14.5.4 Central and Eastern Basins**

Neutralised AMD, and on occasion raw AMD, was discharged by mines in both the Central and Eastern Basins. This ceased at varying times in the past, and subsequent flows have flushed the systems as far as is probably practical. Neutralised AMD will again be discharged in the Central and Eastern Basins in January 2014 and early 2015. The water quality should be monitored and the environmental impacts assessed. However, no specific rehabilitation is proposed for these basins at this stage.

## **14.5.5 Principles**

It is recommended that the remediation of prior impacts caused by AMD only be commenced after the implementation of the LTS (the LTS can be seen to be part of the rehabilitation process), when the water quality, and the discharge volumes (if any) are stable. Rehabilitation interventions to the current state are not advisable, as the state of the river system will change with commissioning of the STI and then the LTS.

Rehabilitation is dependent on the source of re-colonising organisms, and will therefore be dependent on the health of downstream systems.

It should be noted that after the implementation of the LTS and even after any rehabilitation is done in the Tweelopies Spruit, other sources of pollution in the catchment, not specifically related to underground AMD, will continue to have an effect. These include non-point sources such as old mine residue deposits as well as point sources such as the discharge of municipal effluent.

Rehabilitation efforts must be well motivated and consider the whole environment which is affecting the rivers.

## **14.5.6 Funding**

Rehabilitation should be initially funded by Government, but may be covered as part of the cost recovery options detailed in Study Report No. 8 (i.e. the application of the polluter pays principle). The cost of rehabilitation should be considered as part of the LTS, and the possibility of cost recovery from the mines should be included in the negotiations on cost recovery for the LTS, particularly in the Western Basin.

## **14.6 Important Supplementary Initiatives**

The recommendations for implementing the STI and LTS, together with the other important initiatives to be coordinated by the Department, will go along the way to manage AMD. There are also other important initiatives which will be the responsibility of other Government and Provincial Departments and which will help to manage AMD.

### 14.6.1 Reduction of Ingress and Pollution

The capital and operating cost estimates for the LTS have shown that significant investments will be necessary to construct and operate the LTS. The OPEX equals the CAPEX every 7 to 10 years. It is therefore crucial to find ways to reduce the costs of managing AMD, whether this is by implementing technologies that can achieve the same objectives but at lower costs, or by reducing the volume of water that must be pumped and treated.

Keeping clean water clean (i.e. preventing unpolluted surface water from entering the mine voids and becoming acidic), and preventing as much ingress, of any water, as possible, is one of the most cost-effective management measures.

In Study Report No. 5.2, the ingress volumes, as well as the potential reduction in ingress if a range of ingress control measures are implemented, were estimated from past studies. The estimated cost savings, if only 50% of the possible reduction is achieved, were also estimated and the results are shown in **Table 14.1**.

**Table 14.1: Possible savings as a result of ingress control (annual savings in R million per Mℓ/d of ingress reduced)**

Basin	Annual Savings							
	Pumping (R mil per Mℓ/d)	Treatment (R mil per Mℓ/d)		Sludge disposal (R mil per Mℓ/d)	Treated water delivery (R mil per Mℓ/d)	Combined saving (R mil per Mℓ/d)	Assumed Possible ingress reduction (Mℓ/d)	Total annual saving (R mil)
		HDS	RO					
Western	0.22	1.45	3.00	1.27	0.12	6.1	5	30.5
Central	0.24	1.39	3.35	0.83	0.20	6.0	10	60
Eastern	0.29	0.88	1.59	0.63	0.20	3.6	21	75.6
<b>Total possible saving with assumed ingress control (R million/a)</b>								<b>166.1</b>

Source: DWA AMD FS 2013, Study Report No. 5 “**Technical Prefeasibility Report**”

It is estimated that R 166.1 million/annum could be saved in operating costs if the total reduction in ingress of 36 Mℓ/d could be achieved.

The DMR, through CGS, has investigated measures to reduce ingress in all three basins. So far, only the Florida Canal has been implemented. It appears that budget constraints and protracted procurement processes are delaying implementation. In the Central Basin, projects with a capital cost of R 80 million, as estimated by CGS, which could reduce ingress by 20.8 Mℓ/d (according to information received from CGS), have been identified and planned, but not yet implemented. They would clearly be cost effective and should be implemented as a matter of urgency. In the Eastern Basin, the CGS is carrying out studies and these should be accelerated and the recommendations for implementing control measures should be fast tracked.

It is unknown just how much ingress comes from leaking municipal infrastructure, but preventing unaccounted water is very significant, and programmes to reduce it should be encouraged and supported. Ingress from leaking sewers is impossible to estimate, but structured sewer maintenance programmes should also be encouraged and supported.

#### **14.6.2 Reprocessing of Mine Dumps and Pollution Control**

GDARD embarked on an initiative to enable the reclamation of mine residue areas for beneficial use. Reclamation is expected to have a significant positive effect on AMD pollution from mine dumps. Moreover, considering that a significant number of informal settlements are springing up in close proximity to mine dumps, the social impact of reclamation, and/or rehabilitation of such land, will be important.

### **14.7 Recommendations for a National AMD Strategy**

The following sections make recommendations with respect to a National Strategy for managing AMD, which is being prepared by the Department.

#### **14.7.1 Changes in Legislation**

It is recommended that the proposed amendments in legislation, as discussed in more detail in the Confidential Study Report No. 3, be considered for incorporation into a National AMD Strategy. The implementation of the adjustments must follow Governmental processes and procedures. The aim of the proposed amendments is to enable Government to have enhanced control and legal administration of the AMD challenges and give more clarity on responsibilities and obligations. This should not only apply after mine closure, but should also enable Government to require pro-active steps long before mine closure.

#### **14.7.2 Studies**

It is recommended that, taking note of the Regional Mine Closure Strategies being prepared by DMR, the Department pro-actively perform studies for different mining areas to consider the possibilities, threats and potential measures to ensure that the future AMD impacts on water resources and measures to limit the impacts are better understood and managed in future. Such studies need to follow an integrated approach across different mining rights areas, and to consider the extent of the challenge, the probable receiving environment, prevention, mitigation, the water resource situation, etc. In this regard, it will be appropriate to make a specific unit in the Department responsible for such studies. The studies need to be managed as an inter-departmental initiative with collaboration with all relevant Departments.

The Study should also consider areas where prospecting licenses and licenses for future mines have been issued. It there are areas where the threat to the water resources is too great to contemplate those areas that should be declared as non-mining areas.

Such holistic and integrated studies then need to inform mine authorisations and the mine plans of individual mines. As such, the planning and development of any new mines need to

be planned “with the end in mind”, and early provision should be made in terms of the future surface water resource, environmental impacts, water use, etc.

### **14.7.3 Trust Funds for Rehabilitation**

Increasing the trust funds that mines provide for rehabilitation should be considered in order to provide for funding the capital and continued operational costs of managing AMD after mine closure.

### **14.7.4 Mine Closure Plans**

Although approval of mine closure plans is a DMR responsibility, there are some key aspects of the plans where the Department should be involved. The National Strategy should define the areas which, from DMR’s perspective, are most critical and where stronger enforcement in mining closure plans, and the requirements and capacity required for enforcement, are most important.

### **14.7.5 Creation of a National AMD Trust Fund**

As a longer-term strategy, the feasibility of the establishment of a National Trust Fund, where all mines contribute towards cost of the prevention, treatment and management of pollution from current mining activities, as well as funding the rehabilitation of the legacy of AMD, should be investigated. NT has commented that the introduction of a mining tax could be considered. This should happen in close consultation with the Chamber of Mines and could function similarly as in other countries such as the United States of America. This aspect needs to be investigated in conjunction with consideration of an Environmental Levy that may be instituted in future. The levy or a mining tax could be a source of revenue for the Trust Fund.

## 15. CONCLUSIONS

This Study has assessed and quantified the AMD problem from the Witwatersrand underground mining basins. Numerous options for abstraction, treatment, water use and residue management have been integrated from possible solutions for each basin. These were assessed to develop a low risk preferred solution for each basin, for which concept designs were developed and costed. A range of approaches to procurement and funding, together with institutional arrangements were assessed and an implementation strategy has been developed. That, together with the complementary and supplementary activities has provided a sound basis for managing AMD on the Witwatersrand. There are many recommended activities and these are summarised in **Table 15.1**.

**Table 15.1: Summary of Recommended Actions and Activities**

Topic	Priority	Actions and Activities	This Report Chapter Reference	Source Report for Details
<b>Organisational and Institutional</b>	A	DWA to confirm use of Implementing Agent and issue Directive for implementation of LTS in Central and Eastern Basins, using agreed contract.	13.8.1a	Report 8
	A	DWA to establish agreements with WRC and DST for implementation of Pilot Treatment Plants Projects in Western Basin	13.4.3a, 13.9.2b	Report 8
	A	Establish DWA Special Project Unit.	13.8.1b	Report 8
<b>Funding</b>	A	DWA to confirm sources of funding to be used for all requirements. Confirm cash flow, including refinancing of STI, if required.	10.5	Report 8
	A	DWA to set up off-take agreement with Rand Water for all three basins.	7.4	Report 8
	A	DWA and/or IA to secure funding for PSPs for support to DWA Special Projects Unit, EIA procurement and associated tasks.	13.8.3	Report 8
<b>Water Use</b>	A	DWA to set up off-take agreement with Rand Water for all three basins.	7.4	Reports 5.3, 6 and 8
<b>Cost Recovery</b>	A	Set up Inter-Departmental Team to negotiate cost recovery from the mines. Agree immediate cost recovery methods to be used and amounts required.	Not discussed here	Report 3
	A	Direct TCTA to carry out VRT calculations.	13.1.2	Report 8
	A	Determine methodology and responsibilities for implementing WDCS.	13.1.3	Report 8
	A	Decide whether the WDCS can be used to finance AMD and if so, the quantum.	13.1.3	Report 8
	A	Determine the appropriate Vaal River Tariff and start consultations to implement it.	13.1.5	Report 8



Topic	Priority	Actions and Activities	This Report Chapter Reference	Source Report for Details
<b>Implementation</b>				
Procurement Contracts	A	Confirm that DBOM contract is to be used.	13.8.1a	Report 8
Land Acquisition	A	DWA to direct TCTA to acquire land for LTS treatment facilities	13.9.1	Report 8
	A	DWA to require Rand Water to acquire land for their treated water delivery pipelines.	13.6.2	Report 8
Western Basin	A	DWA/TCTA to assess Mintails process and agree on neutralisation process for next 5 to 10 years.	13.9.2a	Report 8
	B	DWA to ensure that Mogale Gold / Mintails mining activities are compliant with all relevant legislation and licensing conditions.	13.6.1b	Report 8
	B	DWA or IA to carry out EIA for Ancillary Works and Pilot Treatment Works.	13.4.3b	Report 8
	B	DWA/WRC/DST to plan implementation of Pilot Works.	13.4.3a	Report 8
Central Basin	A	DWA to direct IA to procure a DBOM contract as envisaged - Carry out EIA for LTS.	13.4.4a	Report 8
Eastern Basin	A	DWA to direct IA to procure a DBOM contract as envisaged - Carry out EIA for LTS.	13.4.4a	Report 8
<b>Monitoring by DWA</b>	A	Establish additional void water level monitoring shafts in the Western and Eastern Basins.	14.2.2	Report 8
	A	Implement water quality monitoring in the void.	14.2.2	Report 8
	B	Implement additional water level and quality monitoring in near surface aquifers	14.2.3	Report 8
	B	Implement additional surface water flow monitoring.	14.2.4	Report 8
	B	Implement additional surface water quality monitoring.	14.2.4	Report 8
<b>Expand Rainfall Monitoring Network</b>	B	DWA to liaise with meteorological services	14.2.1	Report 8
<b>Assessment of Monitoring and Operations</b>	A	Determine who will be responsible – recommend that it be Implementing Agent, and include in Directive.	14.2.1	Report 8

Topic	Priority	Actions and Activities	This Report Chapter Reference	Source Report for Details
	B	Evaluate all monitoring results and monitoring and operations accordingly.	13.10	Report 8
<b>Communications</b>	A	Develop an overarching and coordinated communication strategy.	14.4	Report 8
	B	Embark on a separate strong public relations/awareness-raising drive in addition to the EIA.	14.4	Report 8
<b>Further Studies and Investigations</b>				
Western Basin	A	Determine who will be responsible for the following studies (recommended that it be the team responsible for implementation in the basin):	14.7.2	This Report
	B	Rehabilitation of Tweelopies Spruit - Condition Assessment and Remediation Plan.	14.5.3	Report 8
	B	Investigate risk of sinkhole development on public roads across dolomite areas	14.3	Reports 5 and 8
	C	Re-assess potential for abstraction by gravity tunnel.	5.9	Reports 5.2 and 5
Central Basin	A	Determine who will be responsible for the following studies (recommend that it be Implementing Agent, and include in Directive):	14.7.2	This Report
	B	Investigate alternative abstraction points.	6.4	Reports 5.2 and 8
	B	Investigate underground waste disposal.	6.4	Report 5.2
Eastern Basin	B	Determine who will be responsible for the following studies (recommend that it be Implementing Agent, and include in Directive)	14.7.2	This Report
	B	Investigate underground waste disposal.	7.4	Report 5.2
<b>Ingress Control</b>	A	IMC and IGTT to ensure that DMR and CGS Studies and plans are given a high priority and adequate resources, including funding.	14.6.1	This Report
	A	Procurement of contracts for design and construction to be fast-tracked in all three basins.	14.6.1	This Report

Priority Classification:

A = Critical Path (commence as soon as possible) or Urgent  
B = High Priority (commence within 12 months)  
C = Commence within 2 years

## REFERENCES

Department of Environmental Affairs (2012). Draft Waste Classification and Management Regulations. Interwaste Environmental Solutions

DWA 2013, National Water Resource Strategy, June 2013 – Second Edition.

DWA AMD FS 2013, Study Report No. 3 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 3: Legal Considerations for Apportionment of Liabilities – DWA Report No.: P RSA 000/00/16312.

DWA AMD FS 2013, Study Report No. 4 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 4: Alternative Approaches for Apportioning Liabilities– DWA Report No.: P RSA 000/00/12412

DWA AMD FS 2013, Study Report No. 5 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5: Technical Prefeasibility Report on the Long-Term Solution – DWA Report No.: P RSA 000/00/16512.

DWA AMD FS 2013, Study Report No. 5.1 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5.1: Current Status of Technical Management of Underground AMD– DWA Report No.: P RSA 000/00/16512/1.

DWA AMD FS 2013, Study Report No. 5.2 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5.2: Assessment of the Water Quantity and Quality of the Witwatersrand Mine Voids – DWA Report No.: P RSA 000/00/16512/2.

DWA AMD FS 2013, Study Report No. 5.3 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5.3: Options for Use or Discharge of Water – DWA Report No.: P RSA 000/00/16512/3.

DWA AMD FS 2013, Study Report No. 5.4 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5.4: Treatment Technology Options – DWA Report No.: P RSA 000/00/16512/4.

DWA AMD FS 2013, Study Report No. 5.5 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 5.5: Options for the Sustainable Management and Use of Residue Products from the Treatment of AMD – DWA Report No.: P RSA 000/00/16512/5.

DWA AMD FS 2013, Study Report No. 6 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 6: Concept Design and Costing Report– DWA Report No.: P RSA 000/00/16612.

DWA AMD FS 2013, Study Report No. 6.1 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 6.1: Conceptual Design Drawings– DWA Report No.: P RSA 000/00/16612/1.

DWA AMD FS 2013, Study Report No. 6.2 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 6.2: Concept Design: Costing Report– DWA Report No.: P RSA 000/00/16612/2.

DWA AMD FS 2013, Study Report No. 7 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 7: Institutional Procurement and Financing Options Report – DWA Report No.: P RSA 000/00/16712.

DWA AMD FS 2013, Study Report No. 8 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins. Study Report No. 8: Implementation Strategy and Action Plan – DWA Report No.: P RSA 000/00/16812.

DWA AMD FS 2013, Study Report No. 9 – Department of Water Affairs (DWA), 2012: Feasibility Study for a Long-Term Solution to address the Acid Mine Drainage Associated with the East, Central and West Rand Underground Mining Basins.

Study Report No. 9: Key Stakeholder Engagement and Communications – DWA  
Report No.: P RSA 000/00/16912

Minimum Requirements for Waste Disposal by Landfill (DWA, 1998).

Department of Water Affairs, South Africa, August 2013. Reconciliation Strategy for the Crocodile West Water Supply System – Maintenance Study.

Department of Water Affairs, South Africa, August 2013. Implementation and Maintenance of the Reconciliation Strategy for the Crocodile (West) Water Supply System.

Department of Water Affairs, South Africa, June 2013. Second Edition – National Water Resource Strategy.

Department of Water Affairs, 2012. Support to the Implementation and Maintenance of the Reconciliation Strategy of the Crocodile (West) Water Supply System.

Department of Water Affairs, 2012. Crocodile (West) River Reconciliation Strategy. DWA Report No. P WMA 03/A31/00/6110/4.

Department of Water Affairs and Forestry, South Africa, March 2009. Vaal River System: Large Bulk Water Supply Reconciliation Strategy.

Department of Water Affairs and Forestry, South Africa, March 2009. Crocodile West River System: Large Bulk Water Supply Reconciliation Strategy, December 2012.

Department of Water Affairs and Forestry, 2005. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.

Department of Water Affairs and Forestry, Third Edition, 2005. Waste Management Series: Minimum Requirements for Waste Disposal by Landfill.

Department of Water Affairs and Forestry, 1998. Minimum Requirements for Waste Disposal by Landfill.

Council for Geoscience (CGS). 2010. Mine Lease Areas in the Western, Far-Western, Eastern, Central and KOSH Basins. Shape File. Developed for the Department of Mineral Resources (DMR), Johannesburg, South Africa.

EScience Associates (Pty) Ltd for the Department of Environmental Affairs (2010). Development of a Revised Waste Classification System for South Africa. Waste Categorization System for WIS Reporting.

Gauteng Department of Agricultural and Rural Development (GDARD) Gauteng Conservation Plan v3 – C-Plan) – Environmental Impacts.

Holland, M. and Witthüser, K. T. (2009) Geochemical characterization of karst groundwater in the Cradle of Humankind World Heritage Site, South Africa. Environmental Geology, Vol. 57, p. 513-524.

National Treasury, March 2004. Standardised Public-Private Partnership Provisions.

Rand Water's Water Demand Projection Study (Rand Water, 2009).

The South African National Standards (SANS), SANS 241: 2012 specifications.

TCTA, 2011. Due Diligence Report – Neutralisation of AMD and Proposals outlined for each basin regarding AMD abstraction, water treatment, treated water discharge and sludge disposal.

Terms of Reference (ToR) for this Feasibility Study (DWA 2011a)

Water Research Commission (WRC) Project, 2013a. Investigating the potential for using AMD from the Witwatersrand Basins for agriculture.

Water Research Commission (WRC) Project, 2013b. The BIOSURE Process: A sustainable, long-term treatment option for Acid Mine Drainage treatment.

Water Research Commission (WRC), 2012. The State of Non-Revenue Water in South Africa (Report No. TT 512/12).